

PART VI

COURSE DESCRIPTIONS

(On-Campus)

LEGEND

The numbers that appear at the end of each course title like 3 0 3, 0 9 3, 2 3 3 etc. indicate the lecture hours per week, the practical/seminar/project hours per week and the number of units in that order. Wherever a single number (with or without*) appears, it indicates only total units and its break up in terms of lectures and practicals/seminar/project may be announced from time to time through the timetable whenever it is needed.

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This part gives a detailed description of all the courses.

Offering of courses: The academic calendar consists of two regular semesters. The summer term is not part of the academic calendar except where specifically stated. The offering of courses shall always depend on the normal unfolding of these courses for regular students who should be able to negotiate all the courses required as compulsory or electives as they proceed within the stated number of years in the programme. Very often any departure from this practice is subject to the overall facilities available. It will be invariably taxing of facilities to help the largest number of students when possible. For instance, same course is offered in both the semesters where only one is necessary, in the pattern described above. Depending upon the need and the facilities, Dean, AUGSD/AGSRD decides the courses that will be offered in any particular semester and this information will be made available through a course-wise timetable at the beginning of every semester.

It will be clear from the above discussion that a student who wishes to exercise his choice of electives can do so only through courses available in the timetable and not courses which are mentioned in the bulletin. Nonetheless, students can easily guess, on the basis of previous timetables, which courses are likely to be offered in what semester and make an advance planning to the extent it is possible. Similarly, a student who has backlog will find that he is already out of phase with the pattern that has been described earlier and therefore has to work out a strategy for himself by which he reduces fouling up as much as it is possible for him to do so.

While registration in a particular course or set of courses is governed by Academic Regulations, for easy reference the following general guidelines together with specific points are listed.

1. The Dean, AUGSD/AGSRD may introduce or withdraw courses in categories which are taken on the basis of electives or options.
2. Registration in any course can be made only with the prior permission of the Dean, AUGSD/AGSRD.
3. Although the detailed break-up of the units in terms of hours for lecture and practical classes are presented without designating tutorial hours, every student will be required to attend these tutorial classes as and when required by the Dean, AUGSD/AGSRD.
4. In the structure of a programme a block of courses follow in a particular sequence semester after semester. The mere fact that no specific restriction has been put does not permit unwarranted jumbling of this sequence. This sequence is presented in semesterwise pattern for each programme.
5. The lists of courses to be followed invariably have numbers attached to each course. These numbers generally determine the level at which the course is to be normally registered. However on the same plane there are courses which are specially designed for group C programmes and are not available to students of groups A&B programmes. Appropriate sections of the Bulletin may be consulted.
6. Sometimes a particular course has a prerequisite condition which has to be fulfilled before one can register in that course, or has to be waived with the consent of the Dean, AUGSD/AGSRD.
7. For registration in certain specific courses like Specialized Discipline Courses, Higher Degree Courses, apart from the prerequisite, there will also be requirement of prior preparation. Academic regulations must be consulted for this.
8. For students registered in courses of Off-Campus Work Integrated Learning and Collaborative Programmes corresponding instructions have been detailed in PART V.

Note: The items mentioned above are not exhaustive. For precise rules reference should be made to Academic Regulations.

Course Description for all On-campus Programmes

Aeronautics

AN F311 Principles of Aerodynamics 3 0 3

Introduction to Airfoils, forces and coefficients, fundamental principles, inviscid incompressible flow, incompressible flow over Airfoils and Finite Wings, Compressible Flow, Subsonic Compressible Flow, Transonic and Supersonic Flow, Hypersonic Flow, Viscous Flow, Exposure to Software tools for Geometry Modelling and Flow field simulation.

Pre-requisite: CE F231 OR CHE F212 OR ME F212 Fluid Mechanics OR MF 218 Transport Phenomena in Manufacturing

AN F312 Aircraft Propulsion 3 0 3

Air breathing engines, Jet engines, Performance parameters of jet engines, Ramjet and pulsejet engines, Thermodynamic and performance analysis of turbojet, turbofan and turboprop engines, Intake, Combustion and Exhaust systems in propulsion engines, Advanced propulsion engines. Exposure to Software Tools for Nozzle Flow and Propulsion Performance Simulations

Pre-requisite: CE F231 OR CHE F212 OR ME F212 Fluid Mechanics OR MF 218 Transport Phenomena in Manufacturing

AN F313 Flight Mechanics and Controls 3 0 3

Introduction to Airplane Flight Mechanics, Equation of Motion (3DOF), Atmosphere and Propulsion, Aerodynamics forces, Cruise and Climb, Take-Off and Landing, Acceleration and Turns, Equation of Motion (6DOF), Static Stability and Control, Dynamic Stability and Control, Feedback Stability Augmentation, Exposure to Software Tools for Flight Path Simulation and Control.

AN F314 Introduction to Flight 3 0 3

Fundamentals and historical developments in Aviation, Standard Atmosphere Properties, Basic Aerodynamics, Airfoils and Wings, Forces, Supersonic Flight, Airplane Performance, Stability and Control, Types of powerplants for aerospace vehicles, Introduction to Structures and Materials, Supersonic and Hypersonic Vehicles, Exposure to Software tools for Wing Geometry Modelling and Force Calculations.

AN F315 Aircraft Structures 3 0 3

Basic elasticity and 2D problems, Virtual work and energy method, Bending of thin plates, Structural components of aircraft, Airworthiness and airframe loads, Bending, Shear and Torsion of Thin-Walled Beams, Stress analysis of aircraft components including Wing spars and box beams, Fuselage, Wings, Fuselage frame and wing ribs, Laminated composite structures, Aeroelasticity, Computational Modelling of various Aircraft Components under Service Loads.

Pre-requisite: ME F211 OR CE F211 Mechanics of Solids

Architectural and Urban Engineering

AUE F211 Basic Design for Visualization 3*

In Basic Design for Visualization, students will explore foundational aspects of design, intertwining both theoretical and practical components. The course will cover a variety of topics including a basic introduction to all aspects of the design process, develop their skills and enable creativity, abstract thinking, representation, iteration and design development, fundamental design principles, conceptualization, visualization, and basic design skills like hand sketching, drafting, and introductory CAD tools utilization. Explore concepts related to form, function, materials, tools, and physical environments through projectbased exercises. Develops familiarity with design process, critical observation, and the translation of design concepts into digital and physical reality. This will also include introductory architectural design and project development within design constraints including architectural program and site.

AUE F212 Structural Mechanics 3 0 3

Importance, and Application in Architecture; Understanding Load, Support, Force System and Resultants, Equilibrium of Force Systems, Free Body Diagrams, Stress and Strain; Stress-strain relationships; Determinacy and Indeterminacy; Bending

Moment and Shear Force Diagrams; Bending stress and shear stress in beams; Plane stress and plane strain transformation; Deflection and slope in beams and frames; Analysis of statically determinate truss; Buckling of columns using Euler's theory; Introduction to modern structural systems and corresponding case studies in the urban context; Introduction to Structural Analysis Software.

AUE F213 Fluid Mechanics and Applications 3 0 3

Introduction to fluid properties- density, viscosity, surface tension Pascal law, Manometers, Buoyancy and Floatation, The continuity equation, The Euler's equation, The momentum equation, The Bernoulli Equation in urban water systems, Dimensional analysis and similitude; Principles of pipe and open channel flow, Hardy cross method, Urban water supply essentials: from sourcing to distribution intricacies. Concluding topics on water aesthetics in urban layouts, urbanization challenges, climate resilience, and advanced hydraulic strategies.

AUE F241 Architectural Design Studio I 3*

Delve into realm of architectural design and involve in the design process by exploring 2D and 3D modes of visual communication, develop a design from concept to form by incorporating spatial and material facets of architecture, focusing on user needs analysis, zoning, spatial relationships, accessibility, and circulation, instruction and practice in oral and written communication, engage in representational and model making techniques, enhance design development skills through iterations, feedback incorporation, and final design presentations, forming a robust grounding in architectural design.

Pre-requisites: AUE F211: Basic Design for Visualization

AUE F242 Building Construction & Technology 3*

This course provides a deep exploration of construction methodologies, for types of foundation, walls, windows, doors, curtain walls, staircases, domes, arches, plates, shells, portal frames, trusses, large span structures etc. Construction methodologies are at the core of building projects, guiding the processes from conception to realization, spanning from traditional practices to contemporary techniques. This comprehensive course equips students with the expertise to create not only visually appealing but also resilient, and architecturally sound structures by application in a project.

AUE F243 Construction Economics 3 0 3

Introduction to Construction Economics, Estimation: Necessity of Estimation, Units and Measurements, Types of Estimates- Methods of Estimation, Types of Estimation - Plinth Area Estimate, Cubical Content Estimate, Unit Rate Estimate, Detailed Estimate, Real world examples in Civil and Architectural context. Specification and Tenders: Data, Schedule of rates, Analysis of rates, Detailed and general specifications, sources, Tenders, Contracts, Types of contracts, Build Operate Transfer (BOT), Arbitration and legal requirements. Valuation: Necessity, Basics of value engineering, Capitalized value, Depreciation, Escalation, Calculation of Standard rent, Mortgage – Lease, Valuation of Building, Loss assessment. Report Preparation, Real world case studies.

AUE F266 Study Project 3

These courses include projects which are oriented towards readings from published literature or books about new frontiers of development or analysis of available database. These courses are normally available to students in second or higher levels. These courses must coterminate with project reports.

AUE F311 Architectural Design Studio II 3*

Complex, large-scale projects that require an integrated design approach, merging aesthetics, function, and technology, addressing contextual and environmental constraints and considering multidisciplinary integration in the design process, advanced spatial planning, sustainable design strategies, technological integration, and addressing socio-cultural aspects within architectural design, group discussion, instructor feedback, peer feedback.

Pre-requisites: AUE F241: Architectural Design Studio I

AUE F312 Geotechnical Design**3 0 3**

Introduction to geotechnical design for architects; Origin and classification of soils; Index properties of soil; Effective stress principle; Permeability and seepage basics; Foundational soil stresses and its implications in architectural design; Site investigations: Methods of drilling, sampling, In-situ tests such as SPT and plate load tests, interpreting field test results; Concepts of shear strength of soil, Basics of earth pressure theories for retaining structures and design considerations; Bearing capacity concepts and settlement issues of shallow foundations; Introduction to deep foundations: Types and selection of piles for architectural design; Basics of slope stability and potential impact on structures; Introduction to ground improvement techniques and their architectural applications; Case Studies from Urban context.

AUE F313 Design of Reinforced Concrete Structures 3 0 3

Engineering properties of different concreting materials; Design Philosophies; Concepts of Limit State Method; Limit State Design for flexure of Singly and doubly reinforced rectangular and flanged section beams, one-way and two-way slabs; Design for Bond, anchorage and development length; Design of beams with rectangular and Flanged sections for Shear; Limit state of serviceability for beams and slabs; Limit State Design for collapse of columns subjected to axial, axial plus uniaxial bending and axial and bi-axial bending; Design of Footings; Design of Stair Cases.

Pre-requisites: AUE F212: Structural Mechanics or CE F211: Mechanics of Solids

Equivalent: CE F320: Design of Reinforced Concrete structures (with prerequisite: CE F211: Mechanics of Solids or AUE F212: Structural Mechanics)

AUE F314 Highway Planning, Analysis and Design 3 1 4

Overview of basic characteristics of Road Transport systems; Transportation Planning Process - Identification of needs, Generation and Evaluation of alternatives; Highway Planning- Feasibility Studies and Surveys - errors, leveling, angle measurement and traverse, areas, earthwork and mass-haul diagram; Highway Geometric Design - Project Development and Design Process, User characteristics, Design Criteria, Horizontal and Vertical Alignment; Traffic Engineering - Fundamentals of Uninterrupted and Interrupted Flow, Data Collection, Capacity and Level-of-Ser-vice Analysis; Design of Traffic Facilities - Signalized and Un-signalized intersections, Interchanges, parking facilities, ; Emerging Transportation Topics - Livability and Sustainability, Transportation System Resilience, Roadway Safety, Disruptive Technologies and Transportation

AUE F341 Urban Planning and Sustainable Communities 3*

Process of planning and designing urban areas that are sustainable, livable, and efficient, urban ecology, transport planning, land-use planning, and the social aspects of urban design, underscoring the importance of creating communities that promote well-being and sustainability, holistic and integrative approaches to urban planning, where economic, social, and environmental aspects are harmoniously balanced exploration of various global case studies, discussions, and practical projects, devise innovative solutions for real-world challenges in urban contexts, focusing on fostering sustainability, inclusivity, and well-being within urban communities.

AUE F342 Building Acoustics and Lighting Design 2

Specialized study of sound and light within built environments, foundational principles of acoustics and lighting, sound absorption, reflection, diffusion, and strategies to optimize acoustic performance within varied spatial contexts natural and artificial lighting strategies, light quality, distribution, and technologies to enhance visual comfort and aesthetics within architectural spaces. practical exercises, simulations, and projects, to apply theoretical knowledge in creating well-lit and acoustically optimized environments.

AUE F343 Design of Steel Structures 3 0 3

Introduction to Limit State Design and Plastic design, Limit state design of bolted and welded connections, Eccentric connection,

Design of Tension Members, Design of Compression Members, Design of Beams, Design of plate girders, Column bases. Exposure to relevant software.

Pre-requisites: AUE F212: Structural Mechanics or CE F211: Mechanics of Solids

Equivalent: CE F343: Design of steel structures (with pre-requisite: CE F211: Mechanics of Solids or AUE F212: Structural Mechanics)

AUE F344 Directed Research in Architecture – I 1

Formulate the problem statement for an architectural design project on the basis of a need in a particular location with an emphasis on practical applications, demonstrate the synthesis of their accumulated knowledge in a final comprehensive design project, formulate the requirements in terms of number and types of users, space type and allocation, etc on basis of literature review and case studies, Prepare a synopsis for the design project to be worked on in AUE F311 Directed Research in Architecture – II

Pre-requisites: AUE F311: Architectural Design Studio II

AUE F345 Directed Research in Architecture – I 4

Work on the problem statement formulated in AUE F344 Directed Research in Architecture – I , develop integrated design skills by negotiating the complex issues of program, site, and form in a specific cultural context, prepare research documents, and developed viewpoints on a topic of importance, original design project that involves additional learning of a practical nature by including case studies, translate architectural concepts and ideas into built environments that transform the public sphere, advanced work must be documented with a report and portfolio with detailed drawings, embodying advanced architectural design principles and methodologies.

Pre-requisites: AUE F344: Directed Research in Architecture – I

AUE F361 Landscape Architecture 3 0 3

Definition & Significance: Role in urban and rural settings. Evolution and History: Brief overview of the discipline's development and influential styles. Site Analysis: Techniques to assess conditions; the essence of contextual design. Design Principles: Exploration of form, space, and color; practical applications. Plant Materials : Basics of horticulture; selection criteria for aesthetics and climate. Hardscape Elements : Introduction to non-living features; materials overview. Environmental Sustainability: Designing sustainably; emphasis on native planting and water management. Urban Design and Public Spaces: Landscape's role in public realms; key design principles. Landscape Technology : Essentials of irrigation, lighting, and drainage. Landscape's reflection of society and culture. Digital Tools, Professional Practice, Field Studies

AUE F362 Building Services 3 0 3

Building Services Overview, Mechanical Services: Plumbing, sanitation, and fire safety mechanisms. Electrical Services: Electrical system essentials, lighting design principles, and communication infrastructure. Vertical Transportation: Introduction to the design and safety aspects of elevators and escalators. Sustainability and Energy Management: Highlighting energy-efficient design approaches, renewable energy applications, and the importance of Building Management Systems (BMS). Security Protocols, Acoustics, Water and Waste, Specialized Building Systems, Practical Exposure.

AUE F366 Laboratory Project 3**AUE F367 Laboratory Project 3**

These courses include projects involving laboratory investigation or laboratory development in the students discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

AUE F376 Design Project 3**AUE F377 Design Project 3**

These courses are intended to impart training in design of product/ process or other artifact to the students in the discipline or

interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

AUE F421 Renewable Energy Systems in Buildings 3 0 3

Comprehensive understanding of integrating sustainable energy solutions into building design and operation. Various renewable energy technologies, including solar, wind, and geothermal systems, and their applications in residential and commercial structures, principles of energy-efficient building design, system integration, and the economic and environmental implications of renewable energy use. Designing, implementing, and evaluating renewable energy systems within the context of sustainable building practices, knowledge and skills needed to address the growing demand for sustainable energy solutions in the construction and operation of buildings.

AUE F422 Urban Mass Transit Planning, Operations 3 1 4 and Management

Modes of public transportation and application of each to urban travel needs; Comparison of transit modes and selection of technology and transit service; Estimating demand in transit planning studies and functional design of transit routes; Terminal design; Management and operation of transit systems, Model for operational management; Fleet and crew management; Terminal management; Fiscal management.

Equivalent: CE G524: Urban Mass Transit Planning, Operations and Management

AUE F423 Machine Learning in Design Optimization 3 0 3

Machine Learning in Design Optimization is an advanced interdisciplinary course that explores the intersection of artificial intelligence and engineering design. The students will understand the fundamentals of machine learning and its applications in design optimization, through key topics like evolutionary algorithms, Neural Networks and Reinforcement Learning for Optimal Control. Through real-world case studies and practical applications, the students will learn how to collect and preprocess data relevant to design optimization, formulate optimization problems, design objective functions and constraints for machine learning-based optimization. The course aims to encourage critical thinking skills, required for selecting appropriate algorithms and models for specific design problems, and how to leverage machine learning algorithms to automate and improve the design optimization process.

AUE F424 Construction Management 3 1 4

Industry profile, parties involved, contracts, bonds, bidding, changes, pre-planning, construction management approach and partnering, Planning and scheduling, network-based scheduling systems (CPM), Resource management, Network acceleration, PERT probabilistic approach.

Equivalent: CE G527: Construction Management

AUE F425 Building Information Modeling 3*

Introduction to Building Information Modeling (BIM): - Concept and evolution, Significance of BIM, Difference between BIM and traditional CAD; BIM Software Tools: Introduction to BIM software (e.g., Autodesk Revit, ArchiCAD), Basic navigation and interface understanding; 3D Modeling: -Creating basic architectural elements: walls, floors, roofs, windows, and doors. Understanding layers, sections, and elevations; Information Management: -Embedding and managing data within BIM models, Use of BIM for facility management; Collaborative Workflows in BIM:- Understanding collaborative work in BIM, Introduction to cloud-based BIM and collaborative tools; BIM and Sustainability:- Using BIM for sustainable design analysis, Energy modeling and analysis with BIM tools; Documentation and Visualization:- Creating construction documents from BIM models, Rendering and visualizing architectural designs; BIM in Project Management:- Using BIM for project scheduling (4D BIM), Cost estimation and budgeting (5D BIM); Analyzing Case Studies and Realworld Application; Practical BIM Project.

AUE F491 Special Project 3

This is an unstructured open-ended course where under the overall supervision of an instructor-in-charge, batches of students will be attached to different instructors. Each batch will work on a specific time-bound project which is of basic or peripheral concern of his discipline. Each student must submit a project report as a culmination of his endeavour and investigation. The instructor-in-charge will determine the choice of the project and also whether or not the project report is to be submitted jointly by a group or individually by a student. The course will aim to evaluate student's actual ability to use the fundamentals of knowledge and to meet new unknown situations as demonstrated by the students' interaction with the instructors and instructor-in-charge and aggregated in the project report. The instructor-in-charge may assign specific hours for formal brain-storming sessions.

Business Administration

BBA F121 Business Ethics and Corporate Social Responsibility 3 0 3

Introduction to business ethics and its significance in the corporate world, Ethical Decision-Making, Stakeholder Theory and Business Ethics, Introduction to Corporate Social Responsibility (CSR), Definition and Components of CSR, Corporate social responsibility and its ethical implications, Ethical Principles in Business, Ethics in the Marketplace and advertising, Environmental ethics, Ethics of Consumer Production, Codes of Conduct and Ethics Policies Role of individual ethics, Ethical Problems in Business/Finance, Ethical Issues in the Workplace, Ethical Leadership, Corporate Citizenship, Ethical Issues in Specific Industries, Global Business Ethics.

BBA F211 Financial and Management Accounting 3 0 3

Introduction to Financial Accounting, International Accounting Standards, Financial Statements, Income Statement, Balance Sheet, Cash Flow Statement, Statement of Changes in equity, Financial Ratio Analysis, Introduction to Management Accounting, Job order and Process costing, Activity-based costing, Cost-volume-profit analysis.

BBA F221 Human Resource Management 3 0 3

Introduction to Human Resource Management, Human Resource Management Strategy And Analysis, Recruitment, Placement, And Talent Management, Job Analysis And The Talent Management Process, Personnel Planning And Recruiting, Employee Testing And Selection, Interviewing Candidates, Training And Development, Performance Management And Appraisal, Managing Careers And Retention, Compensation, Establishing Strategic Pay Plans, Pay For Performance And Financial Incentives, Benefits And Services, Building Positive Safety, Health, And Risk Management, Managing Human Resources In Small, Future Of Work And Changing Dynamics.

BBA F222 Business Law and Compliance 3 0 3

Foundations of business law, intellectual property, employment law, ethics, and corporate governance, compliance, legal requirements and industry standards, and ethical principles, legal responsibilities and obligations of businesses, dispute regulation, issues related to contracts, liabilities, and risk management, legal implications of emerging technologies, international dimensions of business law, environmental law.

BBA F266 Study Project 3

These courses include projects which are oriented towards readings from published literature or books about new frontiers of development or analysis of available database. These courses are normally available to students in second or higher levels. These courses must coterminate with project reports.

BBA F311 Design Thinking 2 2 4

Introduction to Design Thinking, Empathize and Define Phases, Ideate Phase, finding solution through ideation prototype and Test Phases, Implementation and Beyond (Generating Product Idea), Product Development, Listening and Empathizing Techniques, Use of Diagrams and Maps in Design Thinking, Mind

mapping, Use to stories in design think, stakeholder validation pitch, Testing.

BBA F321 Digital Enterprises

3 0 3

Introduction to electronic commerce, technology infrastructure: the internet and the world wide web local area network , protocols, wide area network , marketing on the web, selling on the web, business-to-business activities: improving efficiency and reducing costs, social networking, mobile commerce, and online auctions, the environment of electronic commerce: legal, ethical, and tax issues, web server hardware and software, electronic commerce software, electronic commerce security, payment systems for electronic commerce, planning for electronic commerce implementation management issues.

BBA F341 Behavioural Finance

3 0 3

Overview of behavioural finance, Overconfidence and individual investors, Overconfidence and professional investors, Disposition effect, Risk perceptions, Prospect theory, Decision frames, Mental accounting Familiarity and representativeness, Behavioural portfolio management, Herding, Social interaction Emotions and investment decisions, Behavioural biases and corporate decision-making (Valuation, capital budgeting, and capital structure), Behavioural biases and corporate decision-making (Dividend policy and mergers and acquisitions), Psychological phenomena, corporate governance and group process, Behavioural finance and the financial crisis.

BBA F342 Fintech

3 0 3

Introduction to FinTech (Financial Technology), finance and technology, technological advancements and traditional financial services, creating new business models, Technology and development of innovative financial products, digital payments, online lending, crowdfunding, blockchain technology, cryptocurrencies, and robo-advisors, key drivers, opportunities, and challenges in the FinTech industry, regulatory and ethical considerations with financial innovation.

BBA F343 Merger and Acquisition

3 0 3

Introduction to Mergers and Acquisitions, strategic, financial, legal, and operational aspects of corporate mergers, acquisitions, and other forms of business combinations, Creating Value through Corporate Restructuring, Evaluating Alternative Exit Strategies, Evaluating a Mergers and Acquisitions opportunity, Value Drivers in Inorganic growth Strategy, Accreting vs Diluting Merger, Merger and Acquisitions – Regulatory Environment, Bidding Tactics; Anti-takeover provisions in Takeover Market, Mechanics and Effectiveness of Hostile Bids, Structuring and Valuation of LBO, Accounting and tax issues in business combinations.

BBA F344 Marketing Channels

3 0 3

Introduction to Marketing Channels, Definition and importance of marketing channels, Overview of channel intermediaries: wholesalers, retailers, agents, and brokers, The role of channels in the marketing mix, Channel Design and Strategy, Understanding customer needs and preferences in channel design, Evaluating channel alternatives: direct and indirect channels, Channel integration and coordination, Strategic alliances and partnerships in channel management, Channel Intermediaries and Their Functions, Channel Behavior and Dynamics, Channel conflict: causes, types, and resolution strategies, Power and influence in marketing channels, Channel leadership and governance, Managing channel relationships and negotiations, Logistics and Supply Chain Management, International Marketing Channels, Global distribution strategies and challenges Cultural considerations in international channel management, Adapting marketing channels to different markets, Legal and regulatory issues in global channels.

BBA F345 Financial Analytics

3 0 3

Introduction to Financial Analytics, relevance and scope financial Analytics, recent trends in financial analytics, Financial Time Series and Their Characteristics: Asset Returns, Distributional Properties of Returns, Review of Statistical Distributions and properties of financial time series, Asset Portfolio Models: Basics of portfolio construction, Markowitz Theorem, Capital Asset Pricing

Model, Diversification and Portfolio Optimization, Modelling Volatility and Risk: Characteristics of volatility. Measuring and modelling risk. Application of Value at Risk (VaR), High-Frequency Data Analysis: Non-synchronous Trading, Bid-Ask Spread of trading Prices, Empirical Characteristics of Trading Data, Models for Price Changes, Duration Models, Modelling Credit Risk: Corporate Liabilities as contingent claims.

BBA F346 Marketing Research

3 0 3

An examination of the concepts and practical methodology used in marketing research. An overview of marketing research process, with emphasis on research design; data instrument design; questionnaire formulation; sampling plans; data collection methods -interviewing, panels; data analysis and use of computer-based information systems for marketing intelligence. Timeseries & Regression based models of sales forecasting, control and evaluation of marketing function and survey methodology are covered. Emphasis will be on cases and research projects. Equivalent: MBA G583: Marketing Research

BBA F347 Marketing Analytics

3 0 3

Fundamentals of Marketing Analytics, Definition and Importance of Marketing Analytics, Role of Data in Marketing Decision-Making, Overview of Key Marketing Analytics Concepts, Data Collection for Marketing, Identifying Relevant Data Sources, Basic Analytical Techniques, Descriptive Analytics: Understanding Past Performance, Key Performance Indicators (KPIs) in Marketing, Introduction to Data Visualization for Marketing Insights, Customer Journey Mapping, Mapping the Customer Journey, Analysing Customer Behaviour through the Sales Funnel, Social Media Analytics Basics, Social Media Metrics and Monitoring, Marketing Reporting.

BBA F348 People Analytics

3 0 3

Introduction to People Analytics, Understanding People Analytics, The Role of HR in Data-Driven Decision-Making, Data Sources for People Analytics, Data Analysis Techniques, Descriptive, Predictive and Prescriptive Analytics, Workforce Planning and Talent Management, Workforce Planning and Optimization, Talent Acquisition and Recruitment Analytics, Employee Retention and Engagement, Performance Management Analytics, Learning and Development Analytics, Diversity and Inclusion Analytics, Employee Well-being and Health Analytics, Ethical Considerations in People Analytics, Implementing People Analytics, Overcoming Challenges in People Analytics.

BBA F349 Training and Development

3 0 3

An overview of training; role of training and development in HRD; opportunities and challenges for training; training and organizational development; Need to conduct Training Need Analysis (TNA), TNA Model, need assessment process: organizational analysis, Training Design and Evaluation, Training Methods, Management Development.

BBA F350 Performance Management

3 0 3

Concept and objectives of performance management system, Process of performance appraisal, issues and challenges in performance appraisal, Compensation, Performance Based Pay Systems, Reward systems, Perceptions of Pay Fairness – the legal environment, Legal Constraints on Pay Systems. Employee Benefits. - retirement benefits, perquisites, non-monetary benefits

BBA F351 Compensation Management

3 0 3

Introduction to Compensation Management, Job Analysis and Evaluation, Compensation Strategies and Philosophies, Market pricing and Salary Surveys, Variable Pay and Incentive Plans, Benefits Administration, Executive Compensation, Compensation Communication, Compensation Administration and Compliance.

BBA F352 Strategic Human Resource Management

3 0 3

Overview of Human Resource Management, Evolution of HRM to SHRM, Importance of aligning HRM with organizational strategy, Strategic Planning and HR alignment, Strategic HR policies

and Practices, KRA, KPI, Employees relations and communication, Training and Development.

BBA F353 Organizational Change and Development 3 0 3

Introduction to Organizational Change and Development, Theories of Organizational Development, Lewins Change Model, Kotters 8 Step, Bridges Transition Model, Organizational Culture and Climate, Resistance to Change, Communication in Change Management, Organizational learning and Innovation, Evaluation and Measurement of Change, Cultural Change and Diversity.

BBA F354 Introduction to Consumer Behaviour 3 0 3

Introduction to consumer behaviour, marketing strategy and consumers, needs and wants, The Cognitive Consumer: Perception, Learning and Memory, Motivation and Affect, Critical thinking about consumer behaviour, Needs and wants, motivation process and strength, involvement, Perceptions on the self, self-concept, gender roles and body image, Personality and brand personality, lifestyles and psychographics, values, Formation of attitudes, attitudes as predictors of behaviour, modifying attitudes, communication effects on attitudes, Modifying attitudes, communication effects on attitudes, The stages in consumer decision-making, situational effects on behaviour, buying and disposing, Post-purchase satisfaction and behavior, opinion leaders, Income and consumer spending patterns, social class and status symbols, Subcultures and consumer identities by age, regions, Cultural selection and diffusion.

BBA F355 International Marketing Strategies 3 0 3

Introduction to International Marketing, Overview of international marketing, Differences between domestic and international marketing, Globalization and its impact on businesses, International marketing challenges and opportunities, Market Entry Strategies, international market research, Product and Service Adaptation, Pricing Strategies in International Markets, Distribution Channels in Global Markets, Promotion and Communication in Global Markets, Managing International Marketing Relationships, Building and maintaining relationships with international partners, Cultural sensitivity in business negotiations, Ethical considerations in international marketing, Resolving conflicts in cross-cultural business environments.

BBA F356 Predictive Analytics 3 0 3

Introduction to Predictive Analytics, Understanding predictive modeling and features, Data Cleaning and Transformation, Exploratory Data Analysis, Regression model, Logistic Regression; Artificial Neural networks, Decision Trees; Unstructured Data Analysis, Clustering Techniques, Ethics and Interpretability in Predictive Analytics.

BBA F366 Laboratory Project 3

BBA F367 Laboratory Project 3

These courses include projects involving laboratory investigation or laboratory development in the students discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

BBA F376 Design Project 3

BBA F377 Design Project 3

These courses are intended to impart training in design of product/ process or other artifact to the students in the discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

BBA F411 Forensic Accounting 3 0 3

Principles and techniques of forensic accounting, accounting and auditing, and financial irregularities, legal proceedings, accounting standards – IFRS, IGAAP and Ind AS, the Impact of toxic assets on a firm's valuation, the Impact of leasing (operating and financial lease) on financial statements, Money laundering cases and financial statements, The Roles of the Auditor and the Forensic Accounting Investigator, Internal Audit: The Second Line

of defense, Potential Red Flags and Fraud Detection Techniques, Legal issues in the Auditing and investigation, Tax planning and forensic accounting.

BBA F412 Islamic Finance 3 0 3

A brief history of Islamic Financial System, Sharia'a Law and Sharia'a Boards: Roles, Responsibility and Membership, Definition, Objectives and the sources of the Sharia'a, Major Norms of Islamic Finance, Different types of Economic system, Evolution of Economic System, Advantages and disadvantages, Different types of Islamic Contracts and principles, Understand how a debit and charge card works, Understand the features of a Savings (Wadiah/Mudaraba) Deposit, Understand mudaraba, i.e. trustee project finance, Understand the basic characteristics of the financing product musharaka, Financing Products (Debt) (Financial Instruments), Concept of ijara or a Leasing facility works. Concept of takaful, Understand the basic characteristics of and different models of takaful, Sukuks or Islamic bonds, Comparison of conventional and Islamic microfinance products.

BBA F413 Sales and Distribution Management 3 0 3

Introduction to Sales Management, Personal Selling and Salesmanship, Sales Force Management, Customer Relationship Management (CRM), Sales Promotion and Negotiation, Distribution Channel Management, Retail Management and Channel Partners, Logistics and Supply Chain Management, International Sales and Distribution.

BBA F414 Introduction to Service Marketing 3 0 3

Foundations for Service Marketing, Introduction to Services, Conceptual Framework of the Book, The Gaps Model of Service Quality, focus on the Customer, Customer Expectations of Service, Customer Perceptions of Service, Understanding Customer Requirements, Listening to Customers through Research, Building Customer Relationships, Service Recovery, Aligning Service Design and Standards, Service Innovation and Design, Customer-Defined Service Standards, Physical Evidence and the Servicescape, Delivering and Performing Service, Employees' Roles in Service, Customers' Roles in Service, Managing Demand and Capacity, Managing Service Promises, Integrated Service Marketing Communications, Pricing of Services, Service and the Bottom Line, Financial and Economic Impact of Service.

BBA F415 Customer Relationship Management 3 0 3

CRM- Definition, Emergence of CRM Practice, Factors responsible for CRM growth, CRM process, framework of CRM, Benefits of CRM, Types of CRM, Scope of CRM, CRM Concepts, Customer Value, Customer Expectation, Customer Satisfaction, Customer Centricity, Customer Acquisition, Customer Retention, Customer Loyalty, Customer Lifetime Value, CRM and Marketing Strategy, CRM Planning and Implementation

BBA F416 Fundamental of Retailing 3 0 3

Understanding the Retail Landscape, Retail Management Basics, Retail Marketing and Merchandising, Customer Service in Retail, Retail purchasing and pricing, Retail marketing and promotion, Inventory Management, Employee Management in Retail, E-commerce and Omnichannel Retail.

BBA F417 Prescriptive Analytics 3 0 3

Introduction to Prescriptive Analytics, Optimization modelling and its types, Linear programming for optimization, Transportation problem, Network models, Introduction to simulations, Simulation modelling for decision making, Types of simulation, Monte Carlo Simulation, Discrete event simulation, Advantage and Disadvantages of simulation modelling, Multi-criteria decision making, Types of Decisions, Taxonomy of MCDM methods, Analytic Hierarchy Process, Analytics network process.

BBA F418 Pricing Analytics 3*

Introduction to theory of revenue management and pricing, Fundamentals of price theory, Segmentation and price differentiation, Break-even analysis, Price sensitivity and willingness-to-pay, Empirical estimations of price-response functions, Price optimization, Markdown optimization, The hedonic pricing model, Revenue Management, Big Data and pricing analytics, Monte Carlo

simulation for pricing decisions, Conjoint analysis for pricing decisions. The course necessarily involves the use of statistical software and programming languages. Equivalent: MPBA G526: Pricing Analytics

BBA F419 Time Series Analysis and Forecasting 3 0 3

Introduction to Time Series Data, Time series plots, Concept of Trend, seasonality and cycles, Autocorrelation and partial autocorrelation, stationary and non-stationary process, White noise process, Random walk process, serial correlation, Unit root tests, timeseries decomposition, Additive and multiplicative decomposition, Detrending and de-seasonalization, Stationarity and Transformation, Introduction to Forecasting Models, Autoregressive (AR) Models, Moving Average (MA) Models, ARIMA Models, ARCH and GARCH models, Box-Jenkins Model, Seasonal Models, Forecast Evaluation Metrics, multivariate forecasting models, Ordinary least squares technique, Vector autoregression models, Granger Causality test, Cointegration and error correction technique.

BBA F420 Work, Health, and Safety 3 0 3

Introduction to Occupational Health and Safety (OHS), Legal Framework and Compliance, Hazard Identification and Risk Assessment, Safety Culture and Leadership, Safety Training and Communication, Emergency Preparedness and Response, Workplace Ergonomics and Well-being, Incident Investigation and Reporting, Safety Audits and Inspections, Emerging Trends in Work Health and Safety.

BBA F421 Leadership Skills 3 0 3

Foundations of Leadership, Self-Awareness and Personal Leadership, Communication and Influencing Skills, Team Leadership and Collaboration, Decision-Making and Problem-Solving, Leading Change and Adaptability, Ethical Leadership and Corporate Social Responsibility, Leadership in the Digital Age, Personal Leadership Development Plan.

BBA F422 International Human Resource Management 3 0 3

Introduction to International HRM, Cultural Intelligence and Diversity Management, Legal and Ethical Considerations, Global Staffing and Talent Acquisition, Compensation and Benefits in Global Contexts, Performance Management and Appraisal, Training and Development in a Global Setting, International Employee Relations, Global Leadership and Expatriate Management.

BBA F423 Talent Management and Development 3 0 3

Understanding the concept, significance, and evolution of talent management in the modern workplace, techniques for attracting and retaining top talent, including employer branding, recruitment methodologies, and retention mechanisms, designing and implementing programs for employee skill development, leadership training, and career progression, challenges, and strategies for managing talent in a globalized business environment.

BBA F424 Strategic Leadership 3 0 3

Definition, importance, and evolution of strategic leadership in contemporary organizations, overview of various leadership theories and styles, their applicability in strategic contexts, Role of emotional intelligence in strategic leadership, strategies for enhancing self-awareness and empathy in leadership roles, fostering a culture of innovation, the role of leaders in promoting and managing innovation, integrating ethical considerations and CSR into strategic leadership practices

BBA F425 Introduction to Logistics Management 3 0 3

Basics and Development of Logistics, Management of the Logistics Function, Logistics as a Success Factor, Strategic Logistics Planning, Logistics controlling, Logistics and Model-Based Decision Making, Structural Organization of Logistics, Process Organization of Logistics, Inter-Organization of Logistics, Basics of Personnel Management, Specific Challenges for Personnel.

BBA F491 Special Project 3

This is an unstructured open-ended course where under the overall supervision of an instructor-in-charge, batches of students

will be attached to different instructors. Each batch will work on a specific time-bound project which is of basic or peripheral concern of his discipline. Each student must submit a project report as a culmination of his endeavour and investigation. The instructor-in-charge will determine the choice of the project and also whether or not the project report is to be submitted jointly by a group or individually by a student. The course will aim to evaluate student's actual ability to use the fundamentals of knowledge and to meet new unknown situations as demonstrated by the students' interaction with the instructors and instructor-in-charge and aggregated in the project report. The instructor-in-charge may assign specific hours for formal brain-storming sessions.

Biological Sciences

BIO F110 Biology laboratory 0 2 1

An introductory level course where students would perform selected experiments of biology in the laboratory so that they appreciate the concepts learnt in theory course. Experiments related to Microscopy and micrometry, quantification of biological macromolecules, chlorophyll estimation, measurement of solvent potential of plant tissue, measurement of parameters related to cell cycle, Experiments related to hematology, DNA quantification from the plant organs; Water analysis.

BIO F111 General Biology 3 0 3

Living systems and their properties; major biological compounds; basic physiological processes; introduction to genetics; environment and evolution.

BIO F201 Introductory Biology 3 1 4

Living systems and their properties; classification of organisms; biochemical pathways operative in organisms; introductory genetics, Introductory recombinant DNA technology, ecology and environmental sciences and related basic labs.

BIO F211 Biological Chemistry 3 0 3

The molecular process of life presents us with a seemingly never ending succession of chemical mechanisms of almost incredible fascination. This course is introduced at the cellular and molecular level and focus upon bio-macromolecules, biosynthesis of macromolecules, energy yielding and requiring processes, genetic information etc. This would help going for higher level activities, appreciation of biochemical problems, evaluation and problem solving. It also includes theory of techniques used in biochemistry and related experiments.

BIO F212 Microbiology 3 1 4

Introduction and classification of microbes; structure, physiology and genetics of microbial cell; isolation, cultivation, physiological and biochemical characterization of microbes; host parasite relationship; microbiology of soil, water and food; physical chemical methods of controlling microbes; antimicrobial drugs; clinical microbiology; and related lab components.

BIO F213 Cell Biology 3 0 3

Types and properties of cells; microscopy; membrane structure, function and transport; endomembrane system and its functions; nuclear organization and functions; ribosomes and protein synthesis; cytoskeleton; cell communication; cell cycle, cell growth and cancer; apoptosis; techniques, related experiments and applications of cell biology.

BIO F214 Integrated Biology 3 0 3

The Integrative Biology course is a course which bridges as well as opens new vistas to a student taking up biology. The course covers two tracks, essentially. The first track introduces the student to the ordering that helps biologists to actually study the vast diversity of the living world. This track would encompass questions related to the origin and evolutionary pathways followed in Nature, as well as the methods followed by biologists to systematically categorize and document them. The second track highlights the uses and applications of biology in everyday life – whether in the economic or in the social realms. Together, the course projects the subject in a way from which the student can

choose and implement his biological knowledge vis-à-vis his/her interests.

BIO F215 Biophysics 3 0 3

A study of molecules and their interaction forces; bio-energetics and physical techniques as applied to biological phenomena and related labs.

BIO F216 Water, Sanitation and Solid Waste Management 3 0 3

Municipal Solid Waste Management in Developing Countries, Planning and Design of Sanitation Systems and Technologies, Introduction to Household Water Treatment and Safe Storage, Introduction to Faecal sludge management.

BIO F217 Laboratory for Water, Sanitation and Solid Waste Management 1 2 3

Chemical oxygen and Biological oxygen demand of wastewater, Total organic carbon analysis, Phosphorus analysis, Kjeldahl Nitrogen analysis – for waste water, estimation of total solids and volatile solids in organic waste, biochemical methane potential of organic waste, struvite precipitation from wastewater and analysis by XRD Microbial fuel cell for wastewater treatment, detection of methanogens by fluorescence microscopy, atomic absorption spectrophotometric analysis of arsenic in water composting of faecal sludge.

BIO F231 Biology Project Laboratory 3

The course includes projects involving laboratory investigation or laboratory development in Biology. The course is normally available to students of second or higher level. The course must co-terminate with a project report.

BIO F241 Ecology and Environmental Sciences 3 0 3

Biotic and abiotic components of environment; limiting factors; regional ecology; ecosystem productivity and trophism; population and community ecology; succession and evolution; pollution; environmental biotechnology; Indian environmental movement. Associated with related labs.

BIO F242 Introduction to Bioinformatics 3 0 3

Introduction to genomic & Proteomics, Biological databases and data mining, sequence similarity search and sequence alignment algorithms, Phylogenetic tree construction algorithms, Protein structure prediction and structure analysis, use of software package in Bioinformatics; Related lab components.

BIO F243 Genetics 3 0 3

Facts and theories of heredity, their relation to the present state of biological theory in general; elements of population genetics; genetics and species concept and related labs.

BIO F244 Instrumental Methods of Analysis 1 3 4

Principles, configuration, applications of instruments like mass spectrophotometer, NMR, UV, IR, X-ray apparatus, atomic spectrophotometer, Fluorescence Spectroscopy, gas chromatography, liquid scintillation spectrophotometer, laser device, high voltage electrophoresis, ultracentrifuge, DTA, TGA, Thermo Cycler-PCR, SDS-PAGE, ELISA etc. The course is specially designed for students in the first degree majoring in experimental sciences and would require groups of students to work with the above instruments in order to appreciate the potentiality of such modern instrumental methods of analysis.

BIO F266 Study Project 3

These courses include projects which are oriented towards readings from published literature or books about new frontiers of development or analysis of available database. These courses are normally available to students in second or higher levels. These courses must co-terminate with project reports.

BIO F311 Recombinant DNA Technology 3 0 3

The course deals with theoretical aspects and lab exposure to selected experiments of recombinant DNA manipulation. Empha-

sis will be placed on procedures to create chimeric molecules using examples from actual experimental work. Vector designing, PCR, qPCR, DNA sequencing, in-vitro mutagenesis, cloning in prokaryotic and eukaryotic systems and whole genome approaches will be covered with related lab components.

BIO F312 Plant Physiology 3 0 3

Basic functional processes in plants; Plant tissue system, Plant-water relations, Gaseous exchange, Stomatal regulations, Mineral nutrition and absorption, Transport of material, Growth and development, Hormones and PGRs, Photoperiodism, Vernalization, Plant defense mechanisms, Stress Physiology and related lab components.

BIO F313 Animal Physiology 3 0 3

Principles and concepts underlying the function of tissues and organ systems in animals, with emphasis on mammalian systems and integration of systems at the level of the whole organism. Several biological systems are considered, including respiratory, circulatory, nervous, endocrine, immune, excretory, muscles, skeletal and reproductive systems. Laboratory session will help to study function of any organ system; Related lab components.

BIO F314 Conservation Biology 2 1 3

Biological diversity: its measurement, value and crisis; conservation at ecosystem, population and species levels; protection, management and restoration of ecosystems; sustainable development and community-based conservation; conservation legislation. Course practicum will be effected through classroom and field activities.

BIO F315 Applied Nutrition and Nutraceuticals 3 0 3

This course will provide a broad framework for understanding the significance of food and nutrition to human health and well-being. Beginning with basic concepts in nutritional biochemistry & microbiology, this course will expand into applied nutrition themes — malnutrition – under-nutrition *versus* over-nutrition, nutrigenomics, clinical nutrition, functional foods & nutraceuticals, food safety and security. The course will also include themes such as industrial development of functional and genotype-specific foods and beverages (example, infant-food formulations), fortified foods, phytochemicals, nutritional databases & personalized nutritional plan, using suitable case-studies

BIO F341 Developmental Biology 3 0 3

Scope and problems in developmental biology; major model organisms (vertebrates, invertebrates and plants) and their life cycles; patterning and axis formation; morphogenesis; organogenesis; nervous system; germ cells and sex; cell differentiation and stem cells; growth, ageing and regeneration; applications of developmental biology. The course will emphasize universal principles that govern the process of development; Related lab components.

BIO F342 Immunology 3 0 3

Introduction to immune system, cell mediated and humoral immunity, immune system in health and disease immunity to infectious diseases, immune mechanisms involved in cancer, immunodeficiency and autoimmunity. Vaccination and transplantation Immunology; Related lab components.

BIO F352 Cell and Tissue Culture Technology 3 1 4

Theories and practices on *in vitro* techniques for plants and animals, development of normal and tumor cell lines, somatic hybridization, monoclonal antibody production, hairy root cultures, secondary metabolite production, scale-up strategies for large scale production of biomass.

BIO F366 Lab Project 3

BIO F367 Lab Project 3

These courses include projects involving laboratory investigation or laboratory development in the students discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must co-terminate with project reports.

BIO F376 Design Project	3
BIO F377 Design Project	3
These courses are intended to impart training in design of product/ process or other artifact to the students in the discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must cotermi- nate with project reports.	
BIO F411 Laboratory	0 9 3
Specially designed for M.Sc. Biological Sciences; cannot be taken by others under any circumstances.	
This laboratory course is designed only for M.Sc. Biological Sciences students and aims to expose the students to and build competence in selected techniques of modern biology.	
BIO F413 Molecular Biology of Cell	3 0 3
Introduction of eukaryotic cell cycle, genetic regulation of cell cycle and differential gene expression during developmental process. In addition, the postulated functions of hitherto accepted non-essential DNA and the functioning of higher eukaryotic genes with unexpected structures in eukaryotic genomes would also be covered.	
BIO F417 Biomolecular Modelling	3 0 3
Biomolecular Conformation, Structural genomics and proteomics, protein folding, Forecefield, Simulation, Conformational analysis, ab initio structure prediction, comparative modeling, lattice models, usage of modeling packages.	
BIO F418 Genetic Engineering Techniques	1 3 4
Experiments on the common molecular biology techniques used in gene manipulation in bacteria and plants; gene cloning procedure in bacteria – from isolation of plasmids to screening of recombinant clones; polymerase chain reaction (PCR) and its applications; gene and protein expression analysis; DNA sequencing; Agrobacterium-mediated gene transfer in plants and introduction to plant cell culture techniques; Use of software for molecular biology.	
BIO F419 Molecular Evolution	3 0 3
Introduction of evolution of macromolecules, reconstruction of evolutionary history of genes and organisms, evolutionary adaptation to temperature, water solute adaptation, dynamics of genes in populations, rates and pattern of nucleotide substitution, evolution of gene duplication and domain shuffling, concreted evolution of multigene family, genome organization and evolution, roles of mutation and selection in molecular evolution.	
BIO F421 Enzymology	3 0 3
Enzyme nomenclature and classification; isolation and purification; structures; kinetics; regulation of enzymatic reactions; evaluation of enzymes and other proteins.	
BIO F422 Fundamental of Tissue Engineering	2 1 3
Cellular Dynamics and Tissue Organization, Morphogenesis, Cell Numbers & Growth, Cell Adhesion & Migration, Cell & Tissue Mechanics, Cell Trafficking & Molecular Transport, Cell and Molecule Delivery, Biomaterials, Host Integration, Stem Cells, Engineered Tissues (Bone, Cartilage, Skin & Liver), Translating tissue engineered products to patients. Hands on/demo for scaffold/hydrogel making and characterization, growing human cells in culture, microscopy and 3D printing.	
BIO F431 Reproductive Physiology	3 0 3
Study of sexual cycles; biochemistry of fertilisation; control of ovarian functions; gonadotropins; pheromones and mammalian reproduction.	
BIO F441 Biochemical Engineering	3 0 3
Principles of Chemical Engineering applied to Bioprocesses; Kinetic Models for growth, substrate utilization and product formation; Biological reaction kinetics and applied enzyme catalysis;	

immobilized biocatalysts; Bioreactor Design and Operation; Fermentation, Upstream & Downstream processing; Novel Bioreactor Configurations; Transport phenomena in Bioprocesses; Instrumentation and control; Bioprocess Optimization and Scale up; Industrial Protein Purification Techniques; Commercial Enzymes & Biopharmaceuticals; Bioprocess Patenting, Economics & Feasibility Studies.

BIO F451 Bioprocess Technology 3 0 3

Bioprocess Principles; Kinetics of Biomass production, substrate utilization and product formation; Kinetics of enzyme catalyzed reactions and applied enzyme catalysis; Fermentation process parameters and controls, Upstream & Downstream processing; Bioreactor Design & Operation; Transport processes in Bioreactors; Novel Bioreactor Configurations; Immobilized biocatalysts; Bioconversion; Protein Purification; Industrial applications of Bioprocesses; Bioprocess Patenting & Economics.

BIO F491 Special Project 3

This is an unstructured open-ended course where under the overall supervision of an instructor-in-charge, batches of students will be attached to different instructors. Each batch will work on a specific time-bound project which is of basic or peripheral concern of his discipline. Each student must submit a project report as a culmination of his endeavour and investigation. The instructor-in-charge will determine the choice of the project and also whether or not the project report is to be submitted jointly by a group or individually by a student. The course will aim to evaluate student's actual ability to use the fundamentals of knowledge and to meet new unknown situations as demonstrated by the students' interaction with the instructors and instructor-in-charge and aggregated in the project report. The instructor-in-charge may assign specific hours for formal brain-storming sessions.

BIO G510 Application of Computers and Statistics in 5 Biology

to data classification, analysis and probability; statistical inference – estimation and hypothesis testing; linear regression and correlation; design of experiments; analysis of variance; non parametric procedures & tests; statistical quality control; experimental design in clinical trials and validation; basic techniques in optimization. Introduction to computer and its components; operating systems; principles and use of standard software packages having application in drug design, development, analysis, etc.; principles of software creation; processing concepts, flow charting and algorithms, programming constructs, programming languages, program development sequence; information systems; need, significance concepts, their analysis, design and implementation; software life cycle with special reference to software planning and maintenance.

BIO G511 Population and Quantitative Genetics 5

Gene pool, allele frequency, genotype frequency, Hardy-Weinberg equilibrium & its complications, non-random breeding, genetic drift, genetic load, gene flow, selection, intensity of selection pressure, inbreeding & artificial selection, natural selection & polymorphism, neutral theory & evolution speciation.

BIO G512 Molecular Mechanism of Gene Expression 3 2 5

Prokaryotic and eukaryotic genomes and their topology: DNA - protein interactions; RNA transcription and transcriptional control; DNA replication; transcription in yeast; RNA processing; translation; mechanism of gene expression in pro and eukaryotes.

BIO G513 Microbial and Fermentation Technology 3 2 5

Metabolic Stoichiometry- energetics, fundamentals of microbes and their morphology, Stoichiometry of cell growth and product formation, fermentation kinetics, phases of growth in batch culture, continuous culture and fed-batch cultures, kinetics of cell growth, product formation and substrate utilization-substrate and product inhibition kinetics, enzyme technology. Industrial Biotechnology- strain selection and improvement, media formulation and sterilization strategies, industrial applications, fermentation and product recovery, preparation of alcohols, antibiotics, organic acids, enzymes, bakery and dairy products, biopharmaceuticals, vaccine production.

BIO G514 Molecular Immunology	3 2 5	BIO G532 Biostatistics and Biomodelling	3 1 4
This course will deal extensively with topics like molecular basis of T and B cell antigen recognition and activation. Immunity to microbes and diseases caused by humoral and cell mediated immune responses will be covered and emphasis placed on congenital and acquired immunodeficiencies. Advanced topics like antibody engineering will be discussed with the help of review articles.		Probability analysis variables in biology; standard deviation and standard errors; correlation and correlation coefficient; regression analysis; significance test; chi-square and goodness of fit; applications of computers in statistics; handling of software on enzyme kinetics and protein sequence analysis; computer analysis of nucleic acid structure.	
BIO G515 Stem Cell and Regenerative Biology	3 1 4	BIO G541 Neural Network Analysis	5
Introduction to stem cells and regenerative biology; embryonic stem cells, adult stem cells, manipulation of stem cells for replacing cells in diseased tissues; transplantation of embryonic and adult stem cells, replacing congenitally defective organs and damaged organs, tissue engineering, biodegradable and biocompatible materials, nano-devices, and regulatory perspectives.		Basic concepts, Characteristics of nerve cells and neurons, Definition of artificial neurons, Algorithms, network topology and functions, Neural network application for learning, expert systems, knowledge representation, speech recognitions and synthesis, visual perception and pattern recognition and language processing: Emphasis will be on a comparative study with biological systems.	
BIO G516 Fermentation Processes	(5*)	BIO G542 Advanced Cell and Molecular Biology	5
Introduction to Fermentation, fermentation processes, microbial organisms in fermentation, strain isolation, improvement and preservation, media formulation, sterilization, metabolic pathways and engineering, metabolite overproduction, detailed case studies on food fermentation including cheese, dairy products, bakery foods, wine, brandy, beer, and food related fermentation including single cell protein, baker's yeast, enzymes, organic acids, antibiotics, amino acids, bio-fuel, industrial alcohol. Preparation of vaccine, insecticides, alkaloids. Microbial transformation, Bioleaching, Fermentation economics.		Eukaryotic cell cycle: restriction point, G1 phase progression, role of cyclins, cancer cell cycles; growth factors and their interaction with receptors: PDGF, EGF, VEGF, FGF, TGF; stress responses: mechanisms molecular biology with special reference to hypoxia; extracellular matrix and adhesion molecules; cytokines: sources, molecular structure, targets and mechanisms of action; apoptosis, caspases and necrosis.	
BIO G517 Recombinant DNA Technology	3*	BIO G544 Bioremediation and Bio-metallurgy	5
The course deals with theoretical aspects of recombinant DNA manipulation. Emphasis will be placed on procedures to create chimeric molecules using examples from actual experimental work. Vector designing, polymerase chain reaction, invitro mutagenesis and cloning in prokaryotic and eukaryotic vectors will be covered.		Applications of microbial metabolism for removal of toxic material from environmental sample and recovery of metals from low grade ore; metal- microbe interaction, comparison of conventional and microbe based processes of treating toxic waste material; steps in bioremediation processes such as preparation of biomass through genetic manipulations, immobilization, batch or continuous processes; applications of microbes in bioleaching process and recovery of copper, gold and nickel with case studies.	
BIO G522 Interferon Technology	3 1 4	BIO G545 Molecular Parasitology & Vector Biology	5
Characterization, Functional activity, broad pleiotropic agents, antiviral, anti-angiogenic, antitumor, anti-proliferative, immunomodulatory effect, specific receptor binding, mechanisms, sequencing, classification, Dosage formulation Therapeutic study, side effects, molecular manipulation and activity profile.		Biology of parasitic diseases and their transmission in human and animal population by vectors/carriers. Molecular aspects of parasite and vector biology, modes of infection, life cycles of parasite and vector, host - parasite interactions, infectivity pattern, mechanisms of drug resistance and immune evasion, methods of diagnosis, prophylaxis, treatments to parasitic diseases and vector control measures.	
BIO G523 Advanced and Applied Microbiology	3 2 5	BIO G551 Membrane Biology	5
Molecular taxonomy, Systematic Microbiology; Study of molecular diversity of microorganisms, clinical microbiology, human-microbe interaction, molecular plant-microbe interaction, applied microbiology and synthetic microbiology.		Concepts of biological membrane, Membrane constituents phospholipids, glycolipids and cholesterol; Membrane bilayers, amphipathic molecules, Self-assembly process; Membrane proteins, lateral and transverse diffusion, fluid mosaic model, Membrane permeability; Organization and dynamics of membrane, Signal transduction, role of carbohydrate components of membrane, Red-cell membrane proteins, Tools and techniques in membrane study: electron microscope, X-ray study, autoradiography and spectrometry. Immune response, Surface properties, Kinetics of membrane-bound processes.	
BIO G524 Animal Cell Technology	3 2 5	BIO G561 Advances in Recombinant DNA Technology	3 2 5
Animal cell and tissue culture from various organisms, types of cell lines, development and maintenance of cell lines, manipulation and applications of cell culture technology for Biotechnological research and therapeutics implication.		Recent advances in high-throughput genomics, proteomics and large-scale mutagenesis; genomics techniques like transcriptome arrays and arrays for whole genome analysis; proteomics analysis techniques like 2D PAGE and MS; understanding genome and protein structures and protein interactions through yeast/bacterial two-hybrid systems; large scale mutagenesis and interference.	
BIO G525 Environmental Biotechnology and Waste Management	3 2 5	BIO G570 Recent Developments in Biology	1 0 1
Applications of biotechnology to the management of environmental problems, role of biotechnology in increasing plant and animal production through biological insecticides, herbicide resistance, mineral cycling, conservation of genetic resources and biological nitrogen-fixation. Use of biotechnological processes in pollution control, bioremediation of toxicants, treatment of domestic and industrial waste will be emphasized. Ethical issues related with the release of genetically modified organisms would also be covered.		The students will be exposed to recent advances / research in the area including but not restricted to animal, plants or microbial systems. There will be emphasis placed on understanding the applications and benefits of the in silico and/or wet lab approaches to the selected topics.	
BIO G526 Cancer Biology	3 2 5		
Basic concepts and molecular basis of cancer, Growth, Regulation and Metastasis, Cancer Immune system Interaction, Cancer therapy, Cancer and Environment, Cancer and society.			

BIO G612 Human Genetics**3 2 5**

Epigenetic and Chromosomal Control of Gene Expression: DNA methylation, Genomic imprinting and mammalian development. DNA damage & repair: Damage control during replication and mitosis, Genome stability and checkpoint control, Disorders related to aberrant DNA repair. Molecular genetics of inherited disorders. Cancer genetics: Genetic analysis of various cancers, tumor suppressor genes, metabolic polymorphisms and cancer susceptibility. Genomics & Proteomics: Human genome project and its applications in Gene therapy, novel drug design approaches.

BIO G631 Membrane and Liposome Tech.**3 1 4**

Membrane structure and biogenesis: techniques for the study of membrane structure and properties; model of membranes; molecular transport mechanisms; techniques of artificial membrane productions; liposomes - structure and characteristics; carrier mechanisms for targeting therapeutic agents; industrial applications of liposomes.

BIO G632 Transgenic Technology**3 2 5**

Transgenic techniques as replacements of traditional breeding practices; understanding faulty gene pool; development of commercial and economically viable tissue culture and their genetic improvement through r-DNA strategies; development of recombinant transplants for improved genomic system.

BIO G641 Cell & Tissue Culture Technology**2 2 4**

Plant and animal cell culture from various organism; types of cell lines; development and maintenance of cell lines; tissue culture for viral growth, hybridization and gene manipulation; hybridoma technology and protoplast fusion.

BIO G642 Experimental Techniques**4**

Specially designed laboratory course which aims to impart training in selected range of techniques such as, salt fractionation, dialysis, PAGE with discontinuous buffer solution, Western Blotting, Ion-exchange chromatography and Gel filtration, Genomic DNA extraction from Human Blood, bacteria, purification of DNA and analysis, polymerase chain reaction, single, double and partial restriction digestion, construction of genomic DNA library, Southern Blotting, Karyotyping, short term lymphocyte culture, RNA extraction and quantification.

BIO G643 Plant Biotechnology**3 2 5**

Plant cell and tissue culture, media constituents, micro propagation and other culture techniques, their applications and limitations, germplasm storage, secondary metabolite production, therapeutic protein and antibody production through plants, promoter designing and inducible promoters, molecular markers and their applications, approaches to influence metabolite partitioning and quality and quantity of plant storage products.

BIO G651 Protein and Enzyme Bioengineering**3 2 5**

Sources, isolation, purification and storage of protein and/or enzymes; kinetics of enzyme catalyzed reactions; biocatalyst reaction engineering; techniques of production and recovery of enzymes; protein and enzyme modification; clinical and industrial applications of free and immobilized enzymes.

BIO G661 Gene Toxicology**3 1 4**

Origin and fundamentals of Gene Toxicity; genotoxic effects in plants and mammalian systems; screening and measurements of genotoxicants; techniques in gene toxicology and their application to human, agricultural and environmental monitoring.

BIO G671 Bioconversion Technology**3 2 5**

Waste and by-product utilization; downstream processing; biogas production; principles of biodegradation process parameters; bioreactor design and operation; exploitation of waste streams enzyme-based bioconversions of high value products.

Biotechnology**BIOT F211 Biological Chemistry****3 0 3**

Chemistry and functions of constituents of cells and tissues; introduction to enzymes; metabolism of carbohydrates, lipids, amino acids; nucleic acids and protein synthesis; vitamins and hormones.

BIOT F212 Microbiology**3 1 4**

Introduction and classification of microbes; structure and physiology of microbial cell; infection and immunity; host parasite relationship; microbiology of milk, air, water and food; physical and chemical methods of controlling microbes; experiments for isolation, cultivation, physiological and biochemical characterization of microbes.

BIOT F213 Cell Biology**3 0 3**

Fundamental processes of life at cellular and sub-cellular levels, cell environments, membrane transport, cell movements, division and control mechanisms.

BIOT F215 Biophysics**3 0 3**

A study of molecules and their interaction forces; bioenergetics and physical techniques as applied to biological phenomena.

BIOT F241 Genetic Engineering Techniques**1 3 4**

Experiments on the common molecular biology techniques used in gene manipulation in bacteria and plants; gene cloning procedure in bacteria – from isolation of plasmids to screening of recombinant clones; polymerase chain reaction (PCR) and its applications; gene and protein expression analysis; DNA sequencing; Agrobacterium-mediated gene transfer in plants and introduction to plant cell culture techniques; Use of software for molecular biology.

BIOT F242 Introduction to Bioinformatics**3 0 3**

Introduction to genomics and proteomics, human genome and other sequencing projects, biological databases and data mining, sequence similarity search and sequence alignment, protein structure prediction and structure analysis, use of software packages in Bioinformatics.

BIOT F243 Genetics**3 0 3**

Facts and theories of heredity, their relation to the present state of biological theory in general; elements of population genetics; genetics and species concept.

BIOT F244 Instrumental Methods of Analysis**1 3 4**

Principles, configuration, applications of instruments like mass spectrophotometer, NMR, UV, IR, X-ray apparatus, atomic spectrophotometer, gas chromatography, liquid scintillation spectrophotometer, laser device, high voltage electrophoresis, ultracentrifuge, DTA, TGA, etc.

BIOT F245 Introduction to Environmental Biotechnology**3 0 3**

Industrial processes, incorporating design and monitoring of waste treatment technologies; microbial removal and degradation of organics pollutants, phytoremediation of soil and water contaminated with toxic metals and radionuclides, wetlands as treatment processes, biofilms, biofilters for vapor-phase wastes, and composting; biosensors in environmental analysis, molecular biology applications in environmental engineering and genetic engineering of organisms for bioremediation.

BIOT F266 Study Project**3**

These courses include projects which are oriented towards readings from published literature or books about new frontiers of development or analysis of available database. These courses are normally available to students in second or higher levels. These courses must coterminate with project reports.

BIOT F311 Recombinant DNA Technology**3 0 3**

The course deals with theoretical aspects of recombinant DNA manipulation. Emphasis will be placed on procedures to create

chemeric molecules using examples from actual experimental work. Vector designing, polymerase chain reaction, invitro mutagenesis and cloning in prokaryotic and eukaryotic vectors will be covered.

BIOT F314 Industrial Microbiology and Bio process 2 2 4 Engineering

Principles and application of fermentation technology with respect to production of value added biotechnological products and strategies of improving production; development of biological processes associated with raw materials preparation to product recovery, relevant to industries as diverse as medical, food and environmental protection.

BIOT F342 Immunology 3 0 3

Introduction to immune system, cell mediated and humoral immunity, allergy, mechanisms of hypersensitivity reactions, immunity to infectious diseases, immune mechanisms involved in cancer and transplantation immunology.

BIOT F343 Experiments in Biotechnology 0 3 3

Advanced molecular biology techniques such as genomic DNA isolation, plasmid DNA, single, double & partial digestion, construction of genomic DNA library, PCR, polymorphism in studies, southern blotting, RNA isolation, Real Time PCR, protein expression and analysis and immuno-histochemical techniques.

BIOT F344 Downstream Processing 2 1 3

Recovery and purification of biologically – produced products including biomass itself, extracellular and intracellular components; Strategies to recover and purify products, separation of insoluble products, cell disruption, separation of soluble products, finishing steps for purification, integration of reaction and separation.

BIOT F345 Proteomics 3 0 3

This course deals with the introduction to proteome, significance and analysis of post-translational modification of proteins, protein-protein interaction. Functions of all protein will be discussed in light of the standard prokaryotic and eukaryotic models. Emphasis will be given on methods of proteomic research, proteome analysis, resolution and identification of proteins.

BIOT F346 Genomics 3 0 3

This course provides an introduction to the field of genomics. It also covers the structure of the human genome, and the strategies that were used to map and sequence the genome, and details how genomic sequence information is utilized for pharmacogenomics, drug discovery and diagnostics. The course also introduces post-genomics technologies such as bioinformatics, functional genomics and comparative genomics.

BIOT F347 Immunotechnology 3 0 3

Immunotechnology is a specialised course, which deals with biotechnological aspects of immunological mechanisms Hybridoma technology and production of monoclonal antibodies, antibody engineering using genetic manipulations, alternatives to hybridoma technology for monoclonal antibodies, designing and building of mAb genes, primary and secondary libraries for antibody genes. Emphasis will be given on the production of humanized and human antibodies. Uses of monoclonal antibodies in diagnosis, therapy of allergic diseases, vaccine production, abzyme, purification, quantification and cytogenetic analysis.

BIOT F352 Cell and Tissue Culture Technology 3 0 3

This course will provide an introduction to theory and application of tissue culture technologies. The details of animal and plant tissue culture will be covered including design of media and large scale production of the animal and plant cells. The course also covers the various techniques of preserving the animal cell lines.

BIOT F366 Lab Project 3

BIOT F367 Lab Project 3

These courses include projects involving laboratory investigation or laboratory development in the students discipline or interdisciplinary areas. These courses are normally available to students

in third or higher levels. These courses must coterminate with project reports.

BIOT F376 Design Project 3

BIOT F377 Design Project 3

These courses are intended to impart training in design of product/ process or other artifact to the students in the discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

BIOT F413 Molecular Biology of the Cell 3 0 3

This course is designed to impart knowledge of molecular biology of the cell. Students will understand the various concepts related to cell structure and function at molecular level. : Molecular biology and nucleus, ultrastructure and cytochemical studies, membrane structure and function. Organelle involved in intracellular transport and cell signaling, cell sorting Cell junctions and adhesion molecules, Cell division and the Cell Cycle.

BIOT F416 Introduction to Pharmaceutical Biotechnol- 3 0 3 ogy

The course is designed to provide advances in drug development, drug delivery systems and pharmaceutical specialties including polypeptides, proteins, viruses, DNA and antibiotics. It covers relevant aspects for the development of new biotechnology based drugs, target identification, downstream processing and formulation. Special emphasis is given on understanding the mechanisms and process involved in diseases.

BIOT F417 Biomolecular Modeling 3 0 3

The course is designed to provide students the first hand experience of potential utility of biomolecular modeling especially in concurrent pharmaceutical research, and in cell and structural biology. It describes the functionality, advantages, and limitations of standard computing strategies for the simulation of biomolecules. Biomolecular Conformation, Structural genomics and Proteomics, Protein folding, Forcefield, simulation, Conformational analysis abinitio structure prediction comparative modeling, lattice models, usage of modeling packages.

BIOT F420 Introduction to Plant Biotechnology 3 0 3

Introduction to plant tissue culture, Micropropagation, Somaclonal variation, meristem culture, Anther culture, Cell suspension culture, Secondary metabolite production, Protoplast isolation and Fusion, cryopreservation, Techniques for Plant Transformation – Agrobacterium and Biolistics, Transgenics in crop Improvement.

BIOT F422 Nanobiotechnology 3 0 3

The course deals with the principles and application of nano- and micro-fabrication methods to build tools for exploring the biological systems. The course includes interdisciplinary aspects of biology and nanotechnology on the principles of microfabrication techniques with a focus on nanoparticles, drug delivery systems, and interactions with molecular and cellular level for biomedical and biological research applications.

BIOT F423 Drug design and delivery 3 0 3

The objective of this course is to give insight into the principles of drug discovery and molecular mechanism of drug action. The course is designed for applications in the pharmaceutical and biotechnology related to identifying and optimizing a drug candidate for clinical development. Special emphasis is given on rational and systematic approaches to the development of novel classes of drugs against diseases and effective treatment.

BIOT F424 Food Biotechnology 3 0 3

The course gives an overview on presence of microorganisms, their activity and control in food. It explores the scientific methods for measuring microorganisms and their products. Preservation techniques of foods, food safety, quality controls and food borne diseases are also discussed. The course also covers food fermentation and use of various microorganisms in preparation of fermented foods at industrial level.

BIOT F491 Special Project 3

Course description is same as "BIO F491"

BIOT F492 Applied Molecular Biology Project 3

This course provides students with an opportunity to apply the tools and skills they have acquired during the program to explore an individual research topic. The course allows students to identify problem areas and work on approaches to solve the problem using research methods. This is a supervised applied research project on a topic related to the field of applied molecular biology with special mention but not limited to diagnostics, human disease biology, therapeutics, pharmaceutical products and interdisciplinary approach in the field of molecular biology. The course requires & involve a significant element of research and analysis, and include project reports, and seminar presentation at the completion.

BITS**BITS F111 Thermodynamics 3 0 3**

Concepts and laws of thermodynamics; macroscopic thermodynamic properties; application to closed and open system; microscopic approach to entropy; equations of state; thermodynamics of nonreacting mixtures.

BITS F112 Technical Report Writing 2 0 2

Overview of communication, elements of effective writing, formal reports, types of reports, preparatory steps for writing reports, methods and sources of data, use of illustrations, oral presentation.

BITS F113 General Mathematics I 3 0 3

I. Review of coordinate geometry, Theory of equations, Progression and series, permutations and combinations, Binomial theorem, Functions: Trigonometric (with identities), Transcendental.

II. One Dimensional Calculus: Limit and continuity, Differentiation, Integration. Applications of derivatives and definite integration.

BITS F114 General Mathematics II 3 0 3

I. Polar coordinates, Function of several variables, Multiple integrals, Vector valued functions.

II. Complex functions and their analyticity.

III. First order and second order ordinary differential equations, Laplace transformations and its applications to ordinary differential equations.

BITS F115 Introduction to Basic Sciences 3 0 3

Introduction to scientific method, The nature of scientific inquiry, The role of observation and experimentation, Forces and Motion, Energy, Waves, Light, Properties of Matter, Chemical Reactions, the Atomic Theory and Chemical Bonding, the nature of living matter, the cell – animal and plant, Viruses, Bacteria, Biodiversity, Ecology and ecosystems.

BITS F121 Introduction to Python 3 0 3

Introduction to Python, analysis of the problem, design, implementation, and testing, Python programming fundamentals: program structure, data types, variables, expressions, assignment; Program control statements: if, else, logical operators, assignment operators, conditional operators, blocks. Program repetition statements: while, for; Data Structures: Lists, tuples, sets and dictionaries; Using functions: writing functions enhance program modularity; String handling, File handling, Exception handling, Object-oriented fundamentals: classes, objects, methods, abstraction, predefined classes; Writing classes: programmer-defined classes, instance data and methods, parameters, overloading, encapsulation.

BITS F122 Introduction to Spreadsheet Analysis 2 0 2

Introduction to Spreadsheets, Basic Formulas and Functions; Worksheets, Arithmetic operations and functions, Data Entry and

Formatting, Data Validation and Error Checking, Advanced Formulas and Functions, Logical Functions, Lookup and Reference Functions, Sorting and Filtering, Creating Charts and Graphs, Data Visualization Using Tables, Scenario Analysis, Linking, Embedding and Importing, Collaborative Features, Creating New Functions using Macros

BITS F123 Introduction to Engineering 3 0 3

Introduction to the different engineering disciplines (e.g., civil, mechanical, electrical, chemical, computer, etc.), Historical development of engineering, Role of engineers in society, Ethical considerations in engineering, Problem-solving methodologies, Basics of physics and mechanics, Introduction to engineering design and the design process, Basic principles of thermodynamics, Sustainable engineering practices, Environmental impact, assessment, Engineering and its influence on society, Business and Engineering.

BITS F201 Material Science and Engineering 3 0 3

Introduction on materials for engineering, structures of metals, ceramics and polymers; crystalline structure imperfections; amorphous and semi-crystalline materials (includes glasses, introduction to polymers); Correlation of structure to properties and engineering functions (mechanical, chemical, electrical, magnetic and optical); phase diagrams; Improving properties by controlled solidification, diffusion or heat treatment; Failure analysis and non-destructive testing; Types of materials (includes synthesis, Fabrication and processing of materials); Polymers and composites, Environmental degradation of materials (corrosion); Evolution of materials (functional materials, Biomimetic materials, energy saving materials etc); Criteria for material selection.

BITS F211 Introduction to IPR 1

Importance & relevance of IPR's in the globalised era; legislation covering IPR's in India; patents, copyrights, trademarks, industrial designs, trade secrets, geographical indications; procedures for filing IPR's in India, WTO, TRIPS agreement and their relevance to agriculture, industry education and service sector and others.

BITS F212 Introduction to Human Rights 1

Relevance of human rights education in India: evolution of human rights and duties, human rights: international norms, human rights and duties in India, redressal mechanisms for human rights violations, deprivation of human rights: core issues; women and human rights and duties, good governance, science and technology and human rights.

BITS F213 Introduction to Environmental Studies 1

Ecosystems, evolution and biodiversity; impact of population and economic growth on the environment; sustainable development and use of resources such as water, food, and energy; environmental quality – waste management, air and water pollution, hazards such as global warming, ozone layer depletion, acid rain, and nuclear accidents; sustaining environmental quality- economic, social, political and ethical issues.

BITS F214 Science, Technology and Modernity 3 0 3

Interrelationship between science, technology and modern society; forms in which beliefs and values of a modern society shape sciences and technologies; forms in which scientific discoveries and technological developments influence and shape modern societies. Scientific Revolution and the emergence of modernity as a social condition; Enlightenment promise of progress within the economic system of capitalism. Some critiques of the received view; recent phase of capitalism and the role of technology in globalization.

BITS F215 Applications of Bio-Medical Instrumentation Techniques in Healthcare 2 0 2

Introduction to biomechanics, neuro-prosthetics based on function- sensory, motor, neuro prosthetics; based on regulation- person, auto regulated as adjuncts or alternates to therapy, implants, prosthetics for vision, audition, pain relief, pharmako-kinetic studies, brain-machine interface –methods, rapid prototyping technique in developing artificial bones, tissues, tendons, cartilages,

and various applications of these techniques in improvement of health-care.

BITS F217 Environment, Development and Climate 3 0 3 Change

Specific topics on environment, development and climate change; regional, national and international climate debates; review of international climate negotiations such as Kyoto, Copenhagen and other declarations; environment problems: causes, sustainability and policies; population, resources and sustainability; population dynamics, capacity and conservation; food security, poverty, impact and global solutions; energy resources: renewable, wind, oil, natural gas, nuclear energy; growth, technology and greenhouse gas emissions, carbon credit; regional impacts of climate change and adaptation strategies; techniques in modeling; water resources and pollution: monsoon, drought, rain-water harvesting, traditional practices in water conservation; case studies.

BITS F218 General Mathematics III 3 0 3

Linear equations and matrices, Determinants, Basis of R^n , Eigen Value, Eigen Vector, Linear transformations on R^n .

Linear Programming: Geometric Solutions, Simplex Method, Duality, Post optimal Analysis, Transportation and Assignment Problem. Nonlinear Programming (Unconstrained optimization).

BITS F219 Process Engineering 2 1 3

Basic concepts related to heat transfer, mass transfer and flow of fluid, processes and equipment involved in extraction and filtration; mixing and granulation; size reduction and classification, evaporation and distillation, drying and crystallization, humidification and dehumidification. Materials of construction. Theory of compression and consolidation of solids.

BITS F221 Practice School I 5

BITS F225 Environmental Studies 3 0 3

Environment, human population, and industrialization; natural resources and the impact of man-made activities on them; structure and function of ecosystem, population ecology, biodiversity and its conservation, overview of natural resources, environmental pollution, social issues and the environment, and environmental impact assessment.

BITS F226 Soft Skills for Professionals 3 0 3

Social Skills: Personality development, Emotional Intelligence, Etiquette. Study Skills: Communication Skills, Academic writing Presentations and Public Speaking, Interviews, Group Discussion. Career Planning Skills: Creative thinking, Ethical Values, Capacity Building: Learn Unlearn & Relearn/Domains knowledge, Leadership and Team Management, Decision making/ Negotiation, Time and Stress Management.

BITS F231 Practice School I 5

All the above courses are run during the summer term only. The operation of all these three courses will be identical in nature. However, BITS F221 will be a required course for all integrated First Degree students with Practice School option. This course is also a prerequisite for BITS F412 Practice School II. BITS F231 may be available only to those students who have successfully cleared BITS F221 and BITS F241 may be available only to those students who have successfully cleared BITS F231. Thus BITS F231 and BITS F241 can be taken by highly motivated students if facilities are available after satisfying the needs of students who have to compulsorily register in BITS F221.

BITS F232 Foundations of Data Structures and Algorithms 3 1 4

Algorithm Analysis – Mathematical preliminaries, Sorting Algorithms, Search Algorithms, Linear Structures, Non-Linear Structures, Hashing, Non-Linear Structures, Graphs and Algorithms.

(Open elective for non-B.E. Computer Science students)

BITS F233 Essentials of Start-up 3*

Problem Identification and Opportunity Discovery through Design

Thinking; Deep understanding of Customer and Markets; Market size estimation; Create a Compelling Value Proposition; Competitive Advantage; Build your minimum viable product (MVP); Lean principles in Startup; Build the Product Roadmap; Financial Feasibility; Go-to-Market Strategy; Managing growth and Targeting Scale; Funding Strategy.

BITS F234 Introduction to Engineering Design 4*

Introduction to Engineering Design is a significant contributor in teaching students how to transform a concept into a tangible reality, in order to test - with confidence - tangible realities by simulating real-world conditions. In this course, students will develop fundamental CAD skills in both the 2D realm (e.g. building plans or circuit design) and the 3D realm (e.g. using fully manipulable animated models that are invaluable tools for visualising complex mechanisms). They will also improve their skills and knowledge in drawing techniques, learn to use specific tools, and learn about the design process. They will also learn how Indian and Australian standards define the common language of graphic communication. These graphically presented virtual realities will also extend into the realm of augmented reality, in which simulations and the real world combine for a totally immersive design experience.

Equivalent: OENG1250 Introduction to Engineering Design offered at RMIT.

BITS F235 Digital Fundamentals 4*

This course is focused on digital literacies for engineers and will equip students with the ability to apply a problem-solving methodology to common engineering problems. Using a problem-based approach, students will develop the skills to design, write, test and debug programmes that improve the world we live in. They will be presented with various types of engineering problems which they will then work through from problem identification and algorithm design through to the implementation phase. As part of this course, they will also be introduced to the syntax and development environment of the engineering software tool MATLAB/Simulink. This course establishes a foundation for engineering programmes that require advanced programming and problem-solving skills such as Electrical & Electronic, Computer & Network, Mechatronic and Automotive Engineering.

Equivalent: OENG1206 Digital Fundamentals offered at RMIT.

BITS F236 Foundations of Artificial Intelligence for 4* STEM

This course introduces the foundations of Artificial Intelligence (AI) tailored to students from a range of health, science, technology, engineering, and math disciplines. AI is a branch of computer science devoted to developing intelligent hardware and software systems. Applications of AI are now widespread in the world of work. It is therefore increasingly important for all health, science, technology, engineering, and math disciplines graduates to have an understanding of the foundations and applications of the field of AI relevant to their own discipline. This course will also challenge the students to consider the impact and ethics of AI on their future profession and society.

Equivalent: COSC2960 Foundations of Artificial Intelligence for STEM.

BITS F237 STEM for Sustainable Development 4*

This course provides students with an introduction, understanding and appreciation of sustainability as applied in contemporary Health and Science, Technology, Engineering and Mathematics (STEM) (including holistic, integrative and interdisciplinary consideration of the sustainable development goals, priorities and future sustainability trends in relation to STEM and health. The course will explore the nexus between topics such as environmental sustainability, climate change, biodiversity, health, food and nutrition and energy and transport and the application of sustainable sciences and technologies such as low carbon technologies, circular and digital economies and advanced manufacturing. Sharing and communication of diverse viewpoints and expertise from across the STEM and health disciplines will be facilitated to enable collaborative action to address real world sustainability problems. This course will also explore how diversity, in-

clusion, reconciliation and equity act as driving forces within sustainability and promote and enable diverse voices to be heard and activated to co-create sustainable futures for society and the environment. Ultimately, the course will encourage and enable the students to bring a sustainability focus, approach and agency into their future studies and resulting careers.

Equivalent: ONPS2702 STEM for Sustainable Development offered at RMIT.

BITS F238 Energy Literacy 1 0 1

Understanding Energy and Energy Conversion, Energy Sources, Energy Use, Conventional Energy Uses and Issues, Energy Conservation and Savings, Impact on Climate Change, Carbon Footprint, Sustainable Energy Solutions, Case Studies.

BITS F239 Evolution of Architecture 2 0 2

Comprehensive exploration of architectural history, spanning from ancient civilizations to contemporary structures, evolution of design philosophies, cultural influences, and technological advancements that have shaped architectural marvels throughout history, interdisciplinary journey encompasses the analysis of iconic structures, influential architects, and the socio-economic factors impacting architectural development. dynamic evolution of architecture, critical appreciation for the built environment and its profound impact on societies across time.

BITS F240 Introduction to Environmental and Sustainable Systems Engineering 3*

Introduction to environmental engineering; Triple bottom line concept; Introduction to systems engineering; Innovation, technology, and sustainability; Social essence of engineering; Circular economy and sustainability; Elements of V-cycle; Project management and systems engineering; Project work covering the essence of environmental and sustainable systems engineering.

This course introduces sustainability as a decision-making framework for design in engineering. In addition to the introduction to sustainability, the course comprises a project and problem-based learning (PBL) project that focuses on applying sustainable design in current engineering practice. Students will work in a group on a specific local project. They will recommend a design suitable for the project scope. The project is open-ended and aims to integrate student's knowledge from concurrent first-year courses. It helps the students to identify and develop those generic skills that they will need in their future career. These include skills such as teamwork, communication, computing, drawing, research, and reflection.

Equivalent: BITS F237: STEM for Sustainable Development (CIVE1266: Introduction to Environmental and Sustainable Systems Engineering offered at RMIT)

BITS F241 Systems Engineering Principles 4*

Defining systems, the systems engineering approach compared to life-cycle engineering; requirements analysis for users and systems; functional analysis for small and large systems; verification and testing; fundamental inputs to capability; a comparison of systems and life-cycle engineering design reviews for small and large systems; systems validation.

This course provides a broad introduction to Systems Engineering Principles in the domain of systems development stages. It covers all lifecycle stages from conceptual design, through detailed design, construction, deployment, operation to decommissioning and recycling.

Equivalent: BITS F236: Foundations of Artificial Intelligence for STEM (MIET2562: Systems Engineering Principles offered at RMIT)

BITS F311 Image Processing 3 0 3

Introduction to Image Processing and Imaging systems, Image sampling, Transforms, Enhancement and Restoration, Coding and Communications, Image Compression, Image understanding, Neural network and PR Approaches.

BITS F312 Neural Networks and Fuzzy Logic 3 0 3

Introduction to neural networks, neural dynamics; activations and signals; activation models; unsupervised and supervised learning rules and their domain of applications; architectures of neural systems; Fuzzy sets, fuzzy binary relations; fuzzy logic, fuzzy reasoning; applications in decision making, control theory, adaptive fuzzy and neural control systems and their comparison; Concepts in control systems : stability, state variable, controllability, regression and optimization; mathematical models in control; conventional controllers : design, tuning; Relations, design of fuzzy control systems; control using ANN; Hybrid control, Neuro-fuzzy, GA and bio-inspired optimized control; Case studies on applications of neural, fuzzy and hybrid techniques.

BITS F313 Multicriterion Decision Making in Engineering and Management 3 0 3

Introduction, Single Objective Optimization, Estimation of weights, Multiobjective optimization, Classification Methods, Discrete Multicriterion Decision Making, Fuzzy Logic based discrete MCDM, Correlation coefficients and group decision making, Advanced topics of decision making, Case studies.

BITS F314 Game Theory and Its Applications 3 0 3

Strategic thinking, Rational choice, Dominance, Rationalizability, Nash equilibrium, Best response functions, Duopoly models and Nash equilibrium therein, Electoral competition, Pure strategy, Mixed strategy, Extensive forms, Sub-game perfect Nash equilibrium, Bayesian Nash equilibrium, Select Applications of Game Theory.

BITS F315 Introduction to Cognitive Neuroscience 3 0 3

Introduction, Methods of Cognitive Neuroscience, Sensation and Perception, Attention & Action, Memory, Emotions, Psycholinguistics, Network Neuroscience, Consumer Neuroscience, Social Cognition and Metacognition.

BITS F316 Nonlinear Dynamics and Chaos 3 0 3

Chaos – definitions, characteristics, and measures; Examples of chaotic systems; Nonlinear dynamics and chaos – state space, Poincare sections, Iterated maps, Period-doubling; Quasi-periodicity, Intermittency, fractals; computer simulations of chaotic systems; Selected topics and applications of chaos theory; Examples will be drawn from different disciplines in science, engineering, and social sciences.

BITS F317 Theoretical Neuroscience 3 3 0 3

Introduction to nervous system: Neurons; central and peripheral nervous systems; nerves; ganglions; brain areas; Neural circuits – few examples; Single neuron modelling: Electrical properties of a neuron; Action potential; Integrate and fire models; Conductance based models - Hodgkin-Huxley model, Morris-Lecar model; Cable equation; Multicompartment models for dendrites; Models for synapses; FitzHugh-Nagumo model; Networks of neurons: Feed forward network; Recurrent networks; Excitatory-Inhibitory networks; Stochastic networks; Encoding and decoding; Firing rate; Spike-train statistics; Receptive fields; Reverse correlation methods; Static nonlinearities; Discrimination; Population decoding; Spike-train decoding; Shannon entropy; Mutual information; Entropy maximization and information; Current trends in theoretical neuroscience.

BITS F319 Negotiation Skills and Techniques

Overview, Negotiation styles, Negotiation process, Tactics in Negotiation, Handling conflicts in negotiation, Best Alternative to a Negotiated Agreement, Communication - Key to Effective Negotiating, Non-verbal communication in Negotiations, Emotions: dealing with others and ourselves, International negotiations, Cross Cultural Issues in Negotiations, Power in negotiation, Workplace Negotiations, Turning Negotiation into a Corporate Capability, Do's and Don'ts of Negotiations, Negotiating over the telephone/ Electronic media, Ethics in negotiation, Negotiation-Exercise.

BITS F320 Managerial Skills**2 0 2**

The role of manager, team building and goal setting, basics of supervision, leadership, decision making, negotiation skills and techniques, how managers communicate, how to interview, process of induction, training and development, delegation, how to appraise employees, how to manage time, use of committees, how to handle meetings, how to handle complaints.

BITS F321 Legal and Economic Environment of Business

Indian contracts act, sale of goods act, negotiable instruments act, companies act, corporate tax laws, consumer protection and unfair trade practices act, FEMA, Industrial policy, macroeconomic environment, fiscal and monetary policy, overview of Indian economy, economic indicators.

BITS F322 Venture Team Development and Organization

Building and managing high performance teams; Multidisciplinary teams; Virtual teams; Homogeneity and diversity in teams; Team building – inspiration, interdependence, interaction and integrity; Leadership; Motivation; Compensation and ESOPs; Negotiation Skills and techniques; Interpersonal skills; Communication skills; Conflict Management; Decision making; SMART goals; Perception and bias; Cultural and emotional intelligence; Permanent and contingent workforce; Causes and remedies of dysfunctional teams.

BITS F323 Venture Finance**3 0 3**

Developing Financial Projections, Alternate forms of Financing, Venture Financing Decisions, Business Valuation and Equity Financing; Angel and Venture Capital Funds; Financing for Growth, IPO and Exit.

BITS F324 Strategy for Entrepreneurs**3 0 3**

Developing vision, mission, goals, objectives for an enterprise; Internal and external business environment; Formulating a business model; New entry strategy; Assessing market segments and competition; Blue ocean strategy and red ocean strategy; Investor profile; Porter's generic strategies and five forces model; Boston Consulting Group (BCG) matrix; SWOT analysis; General Electrical Matrix; Core competency; Growth strategies; Stability strategies; Renewal strategies; Indirect assault strategies; Competitor growth limiting strategies; Functional strategies; Strategic myopia.

BITS F325 New Product and Service Design**3 0 3**

New product and service design: standardization, mass customization, delayed differentiation, modular design, and robust design. Defining requirements and specifications. Technical, business and financial feasibility of design. Prototyping, manufacturing and testing. Product and Service lifecycle. Customer satisfaction and sustainability. Reliability. Legal and Ethical considerations.

BITS F326 Design Thinking for Innovation & Entrepreneurship**3 0 3**

Design thinking and innovation mind-set; Creative confidence; Design thinking process; Design thinking – need finding and empathy; Idea generation; Prototyping and experimentation; Human centred design ethos; Innovation through brainstorming; Innovation through prototyping; Innovation by design; Case studies for innovation in all spheres: product, service, business, finance/investments, marketing; Designing a startup; Designing in teams; Designing to use; Design thinking in innovation to handle the unexpected; Innovating within the framework of entrepreneurship.

BITS F327 Artificial Intelligence for Robotics**3 0 3**

Introduction to AI, Application of AI in Robotics. Introduction to Robot Operating Systems (ROS), Python and programming with application of Raspberry-Pi and Arduino. Practical Robot Design Process, implementation of pick and place process. Basic robot sensing techniques (Vision and Listening), Beam Models of Range Finders, sensor models. Object Recognition Using Neural

Networks and Supervised Learning. Robot learning process, Reinforcement learning and Genetic Algorithms. Basic concepts of speech recognition and natural language. Path planning, SLAM, decision trees, classification techniques, wave front, the A* (A star) and D* (D star) algorithms, and node-based planners. Non-deterministic simulation technique and Monte Carlo modeling, the Robot Emotion Engine, the Human Emotion Model.

BITS F328 Innovation Ecosystem and the Future of Work

This course deals with the concepts of innovator in study, work and life. This course will broaden and strengthen student's innovation effectiveness. Students will discover how technology, society, governments, and global trends drive change in the future of work over the span of their career. Students will gain a holistic view of innovation - of self, others, and the task. Understand how bringing people and project together in innovation ecosystems brings new ideas to life, strategically delivering an innovation's true value into the hands of adopters. The course is richly illustrated with fast-paced interactive learning activities and topics. Concepts will be brought to life through stories from alumni students, STEM industry leaders both locally and international. The engaging workshops, serious games and assessment will bring the topics together and provide them with the opportunity to apply their discipline insight as they build their skills and knowledge.

Whether students are a collaborator or leader in innovation, both the skills and an innovators mindset are highly valued by industry. Yet, student's may find that it is of more significant personal value as a strategy for a resilient, vibrant, and fulfilling career in a future of accelerating change.

Equivalent: OENG1235 Innovation Ecosystem and the Future of Work offered at RMIT.

BITS F329 Social and Environmental Applications of Data Science**4***

The course will provide a platform for students to apply data science principles, techniques, and tools to solve problems related to climate and health. The course will expose students to real life problems. The course will also allow students to correlate climate change to health. The applications will be inherently interdisciplinary in nature, and could involve co-supervision by BITS Pilani faculty in departments other than CSIS.

This is a projects-based course for imparting hands-on experience of Data Science for Climate and Health. Students will work in groups and undertake 2 projects: one focused on Data Science either for Climate or Health (termed DS(C) or DS(H)); and a second project focused on Data Science for Climate and Health (termed DS(CH)).

BITS F330 Negotiation Skills and Techniques**3***

Negotiation: Introduction and Overview, Negotiation Styles, Negotiation Process, Preparation, Concessions, First Offer, Best Alternative To a Negotiated Agreement (BATNA), Negotiation Plays: Strategy and Tactics in Negotiation, Handling Conflicts in Negotiation, Communication - Key to Effective Negotiating, Non-verbal Communication in Negotiations, Emotions: Dealing with Others and Ourselves, Power in Negotiation, Ethics in Negotiation, International Negotiations, Cross Cultural Issues in Negotiations

BITS F331 Quantum Computation and Information I**3***

History and scope, introduction to quantum information, quantum bits (qubits), quantum parallelism, teleportation etc; Basic ideas of quantum systems - two-state systems, evolution of states, superposition, entanglement, quantum measurement, decoherence; Basic ideas of computation theories and models: computational resources, complexity; Quantum Gates - single qubit and multiple qubit gates, controlled gates, universal gates, measurement; Quantum algorithms - Deutsch's, Shor's and Grover's Algorithms; quantum circuits, quantum Fourier Transform and applications, quantum search algorithm; Physical Implementation of quantum computation Compression and transmission of quantum information, quantum noise, error-correction, coding and cryptography, complexity, fault-tolerant computation.

BITS F333 Project on Organisational Aspects 3 0 3

These courses involve projects related to thrust areas where students are expected to get involved with planning, organisation and execution of new ideas and concepts. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

BITS F334 Project on Organisational Aspects 3

These courses involve projects related to thrust areas where students are expected to get involved with planning, organisation and execution of new ideas and concepts. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

BITS F343 Fuzzy Logic and Applications 3

Fuzzy sets, fuzzy binary relations; fuzzy logic, fuzzy reasoning; applications in decision making, control theory, expert systems, artificial intelligence etc.

BITS F345 Information Law and Cyber Law 3 0 3

Information related crimes and Cyber-crimes and methods to contain them; National and International laws and IT acts. Economic considerations related to the use and management of digital data; Legal and policy issues, rights, responsibilities, and potential liabilities of parties in information exchange and digital transactions; Cyber laws; Introduction to intellectual property, IPR, legal and technical aspects; Digital rights management: Tools, Standards and Techniques.

BITS F351 Nonlinear Dynamics and Chaos 3 0 3

Dissipative systems; Bifurcations in maps & differential equations (1-d, 2-d, 3-d) – saddle node, transcritical, pitchfork, Hopf, etc.; Application of bifurcation analysis to various systems in natural & engineering sciences; Chaos; Routes to chaos; Quasiperiodicity; Intermittency; Fractals & strange attractors; Conservative systems.

BITS F364 Human Computer Interaction 3 0 3

Principles of human-computer interaction; Evaluation of user interfaces; Usability engineering; Task analysis, user-centered design, and prototyping; Conceptual models and metaphors; Software design rationale; Design of windows, menus, and commands. Voice and natural language I/O; Response time and feedback; Color, icons, and sound; Internationalization and localization; User interface architectures and APIs.

BITS F372 Data Communications and Networks 3 0 3

Communication Concepts; Data and Voice Communications; Hardware Systems and Configurations; Network Topologies and Design Aspects; Protocols; Networking Software; Local Area Networks; Network Security and Management; Emerging Trends in Communications.

BITS F381 TIC Projects 3 0 3

These courses provide an avenue for first degree students who are normally in third year or in a higher class, to earn a letter grade credit for doing projects under the Technology Innovation Centre. These projects are sponsored by the industries which come to the Institute under the scheme for participating in Technology Innovation Centre. The projects are also supervised and monitored by the personnel from industry who visit as Associate Faculty. These courses are unstructured and would require all the rigor which the industry would demand.

BITS F382 Reading Course 3**BITS F383 TIC Projects 3**

These courses provide an avenue for first degree students who are normally in third year or in a higher class, to earn a letter grade credit for doing projects under the Technology Innovation Centre. These projects are sponsored by the industries which come to the Institute under the scheme for participating in Technology Innovation Centre. The projects are also supervised and monitored by the personnel from industry who visit as Associate

Faculty. These courses are unstructured and would require all the rigor which the industry would demand.

BITS F385 Introduction to Gender Studies 3

Introduction to gender studies, Sociological theories about gender, Women's access to education, interest, access and role in science and technology from gender perspective, Gender bias, work place, women and employment opportunities, Women and Politics, women in *Panchayati Raj* Institutions, women and family, women and violence, dowry, women and law, women's movements, feminism, women and human rights, women and media, gender equity-policy issues, women and development.

BITS F386 Quantum Information and Computation 3 0 3

History and scope, introduction to quantum information, quantum bits (qubits), quantum parallelism, teleportation etc. Basic ideas of quantum systems, two-state systems, evolution of states, superposition, entanglement, quantum measurement, decoherence. Basic ideas of computation theories and models, computational resources, complexity. Quantum Gates: single qubit, multiple qubit gates, controlled gates, universal gates, measurement. Quantum algorithms, Deutsch', Shor's and Grover's Algorithms, quantum circuits. Quantum Fourier Transform and applications, Quantum Search Algorithm. Physical Implementation of quantum computation. Compression and transmission of quantum information, quantum noise, error-correction, coding and cryptography, complexity, fault-tolerant computation.

BITS F398 Creative Multimedia 3 0 3

Imaginative and creative communication skills, interactive multimedia applications incorporating various aspects of rich media; digital screen design, typography, non linear editing, animation techniques, sound design and editing, testing and managing multimedia products, post production techniques.

BITS F399 Humanistic Theories of Science and Technology 2 2 3

Ways of considering the interrelationship among three of the major dimensions of our culture: its science, its technology and its humanistic orientation. Alternative ways of thinking about science and technology, diverse approaches of humanistic scholarship to studying science and technology, along with their historical sources. Approaches by social scientists to analyze technical fields of science and technology.

BITS F407 Selected Readings 3 0 3

The course is intended to nurture the students critical thinking and to enhance their skills at information gathering and expressing. Selected readings from books in the areas of History, Science & Technology, Culture, Literature, Art, Philosophy, Psychology, Religion, Development Concepts and Trends etc. will be assigned to the students. A set of books will be identified in at least two broad areas for study and analysis.

BITS F412 Practice School II 2 0 3**BITS F413 Practice School II 2 0**

The above two courses will be operated identically with stipulated prior preparation conditions as per the Academic Regulations. BITS F412 is a required course for all students with Practice School option either for a single degree or for one of the degrees under dual degree scheme. BITS F413 has been created as a required course if a dual degree student is permitted a Practice School option for a second degree after he has completed Thesis option for one degree.

BITS F414 Introduction to Bioinformatics 20

Introduction to genomics and proteomics, Human genome and other sequencing projects; Biological database and data mining; Similarity search and sequence alignment; Protein structure prediction and structure analysis; Use of software package in bioinformatics.

BITS F415 Introduction to MEMS**3 1 4**

Overview, history and industry perspective; working principles; mechanics and dynamics, thermofluid engineering; scaling law; microactuators, microsensors and microelectromechanical systems; microsystem design, modeling and simulation; materials; packaging; microfabrication: bulk, surface, LIGA etc; micromanufacturing; microfluidics; microrobotics; case studies.

BITS F416 Introduction to Nanoscience**3 1 4**

Introduction; nanoscience in nature; fundamental science behind nanomaterials; synthesis and properties of nanomaterials; tools to study the properties, size and shape determinations, application of nanomaterials in science, engineering and biomedical field; future trends.

BITS F417 Microfluidics and Its Application**4***

Introduction to microfluidics, scaling in microfluidics, theoretical microfluidics, Philosophy of Computational Fluid Dynamics, Concepts of discretization, fabrication techniques for microfluidic devices, microvalves, micropumps, microflow sensors, microfluidics for life sciences: micromixers, microneedles, microfilters, microseparators, microreactors, modeling and simulation on CAD tool.

BITS F418 Introduction to Biomedical Engineering**3 1 4**

Introduction; Engineering principals applied for physiological phenomena; Bio implant materials: Metallic, ceramics; Polymeric materials for bio applications; Protein-biomaterial surface Interactions; Modification of surface of the biomaterials; Tissue engineering; Drug delivery systems, principals, and applications; Biomedical sensors; Modeling and simulation.

BITS F419 Management of Cross-cultural Engineering Teams

Characteristics of open technological innovation in competitive global market. The dynamic interaction between technological innovation and market competition – the S-curves. Standard battles to shape the dominant design of a new technology – Cross-the-Chasm and timing of entry. Competitive strategy of companies in different market segments – the Segment-Zero Principle. Commoditization of technology and product on global market – outsourcing and off-shoring. Blueocean strategy to innovate new breakthrough products.

BITS F421T Thesis**3 0 3****BITS F422T Thesis**

The above two courses will be operated identically with stipulated prior preparation conditions as per the Academic Regulations. BITS F421 is a required course for all students with Thesis option either for a single degree or for one of the degrees under dual degree scheme. BITS F421 and BITS F422 have been created as required courses if a dual degree student is permitted Thesis option for a second degree after he has completed Thesis option for one degree.

BITS F423T Thesis**16****BITS F424T Thesis**

Course description of the above two courses is same as given under BITS F421T/BITS F422T. However Thesis with this course number will be available with concurrent coursework for at most 9 Units over a full semester duration.

BITS F427 Digital Marketing**3 0 3**

Fundamentals of e-Business and Internet Marketing, e-Business Models and Frameworks, Digital Marketing Strategy, Online Public Relations, Search Engine Optimization and Marketing, Content Marketing, E-Mail Marketing, Social Media Marketing, Mobile Marketing, Optimizing Customer and User Experience, Web Analytics.

BITS F428 Essentials of Strategic Management**3 0 3**

Difference between Strategy and Organizational effectiveness; Tools for internal and external strategic analyses; Environmental

Scanning and Industry Analysis; Market opportunities and internal sources of competitive advantage; Value chain analysis; Corporate level, Business level and Functional strategies; Strategy implementation.

BITS F429 Nanotechnology for Renewable Energy and Environment

Basics of nano physics, macro vs. nano. Solar cells: Organic solar cell, quantum dot solar cell, dye sensitized solar cell. Self cleaning in solar panel. Fuel cell: Nano electrode and catalysts. Batteries: Nano electrode based batteries. Catalysts: H₂ production and H₂ storage. Carbon nano tube for energy. wind energy: Nanocomposites, nanocoating, and nanolubricants. Nanotechnology as tool for sustainability. Environmental fate & transport of nanomaterials. Nanomaterials for ground water remediation. Nanomaterials as adsorbents. Toxicity of nanomaterials, Ecotoxicological impacts of nanomaterials, Societal implications of nanotechnology.

Pre-requisites

BITS F201: Material Science and Engineering (Pre-requisite) OR CHEM F333: Chemistry of Materials (Pre-requisite) OR PHY F414: Physics of Advanced Materials (Pre-requisite) OR CHE F243: Material Science and Engineering (Pre-requisite) OR ME F213: Materials Science and Engineering (Pre-requisite) OR MF F213: Materials Science and Engineering (Pre-requisite).

BITS F430 Renewable Energy Laboratory**3 1 4**

Experiments on generation of photovoltaic power, wind energy, geothermal energy, fuel cell energy, piezoelectric energy harvesting, smart grid, micro grid, etc.

BITS F431 Flexible Manufacturing Systems**0 2 2**

Introduction CAD/CAM systems, overview of FMS, system hardware and general functions, material handling system, work holding systems, cutting tools and tool management, physical planning of system, software structure functions and description, cleaning and automated inspection, communications and computer networks for manufacturing, quantification of flexibility, human factors in manufacturing, FMS and CIM in action (case studies), justification of FMS, modelling for design, planning and operation of FMS.

BITS F433 Supply Chain Analytics**3 2 4**

Introduction to supply chain analytics, Data understanding and data preparation, Supply chain performance, Descriptive analytics, Predictive analytics and setting up the problem, Supply chain forecasting, studying holt, winter and ARIMA models, Supply chain Network Planning, Multi echelon network optimization, Supply chain sales and operations planning, Supply chain segmentation, Vehicle routing problems, Supervised and Unsupervised learning, Use of Bayesian networks in supply chain, Simulation and SC models, Supply chain risk management.

BITS F437 Technical Communication**3 1 4**

Overview of technical communication, verbal and non-verbal communication, elements of effective writing, technical report, technical proposal, research paper, dissertation, thesis, presentations and group discussions.

BITS F441 Robotics**3 0 3**

The objective of this course is to make the students familiar with Robotics, the main components of kinematics, sensors, transmission and drives, control systems, intelligence and vision, geometric modelling and reasoning, assembly planning, grasping, collision avoidance, mobile robots, force strategies, uncertainty analysis, and representation of visual world.

BITS F442 Remote Sensing and Image Processing**3**

Introduction to remote sensing; types of sensors; earth resource sensors; Landsat; IRS; SPOT; microwave remote sensing; SAR; SLAR; thermal infrared remote sensing; data analysis; image processing; smoothing; filtering; image averaging; enhancement techniques; transforms; FFT; PCA; segmentation; gradient operators; pattern recognition; ML classifier; minimum distance clas-

sifier; other classifiers; ISODATA clustering; feature selection; divergence; canonical analysis; recent developments in remote sensing; LIDAR; imaging spectroscopy etc.

BITS F444 Artificial Intelligence 3

The object of this course is to give an introduction to the problems and techniques of A.I. along with the applications of A.I. techniques to the fields like natural language understanding, image processing, game theory and problem solving.

BITS F445 Neural Networks and Applications 3

Introduction to neural networks and fuzzy systems' neural dynamics; activations and signals; activation models; unsupervised and supervised learning rules and their domain of applications; architectures of neural systems; adaptive fuzzy and neural control systems and their comparison; case studies on fuzzy and neural control systems.

BITS F446 Pattern Recognition 3 0 3

The object of this course is to study the principles and available techniques for the analysis and design of pattern recognition system, introduction to pattern classification by distance functions, and likelihood functions, trainable pattern classifiers: deterministic and statistical approach.

BITS F447 Multimedia Computing 3

Introduction to multimedia; media & data streams; image, video & audio file formats; image & video processing, synthesis of sound signal; image coding & compression, video & audio codecs, low bit rate video telephony; audio-visual integration, lip reading, face animation; augmented reality; multimedia search services, content based image & video indexing; access to multimedia, human-machine interfaces, spoken language interface; algorithm vs. architecture based approaches, multimedia processors, performance quantification; case studies, vision 2010.

BITS F448 Retail Management Systems 3 0 3

Retailing history and theories, basic retail management process, retail industry in Indian and abroad, shopper behavior in retailing, retailing formats and location related issues, category management, supply chain management in retail, retail buying, store layout and design, point of purchase communication, retail pricing strategy, building store loyalty and technology in retailing. Case studies and projects in retailing, specially focusing on Indian scenarios.

BITS F449 Financial Engineering 3 0 3

Introduction; Review of Markets, Players, and Conventions; Cash Flow Engineering with Forward Contracts; Engineering Simple Interest Rate Derivatives; Swap Engineering; Report Market Strategies; Dynamic Replication Methods and Synthetics; Mechanics of Options; Options Engineering with Applications; Pricing Tools; Applications of Fundamental Theorem of Finance; Fixed Income Engineering; Tools for Volatility Engineering: Volatility Swaps and Volatility Trading; Engineering of Equity Instruments: Pricing and Replication, computational methods such as Monte Carlo Simulation.

BITS F451 Autonomous Mobile Robotics 3 0 3

Kinematics, Dynamics and Control of Mobile Robots, Path planning, Roadmaps, Cell decomposition, Sensors for mobile robots, Sensor fusion algorithms, Autonomous navigation algorithms.

BITS F452 Blockchain Technology 3 0 3

Blockchain Technology, and its applications, Cryptocurrencies, Distributed Ledger Technology, Decentralized Systems, Blockchain Data Structure, Cryptography for Blockchain, Decentralized Identity Management, Consensus Mechanism, Smart contracts, Ethereum, Ethereum Virtual Machine, Distributed App development, Consortium Blockchain, Hyperledger, Case studies/Enabling Technologies and applications

BITS F453 Computational Learning Theory 3 0 3

Empirical Risk Minimization, Structural Risk Minimization, PAC learning, The Rademacher Complexity, Error Decomposition, VC

dimension, Convexity, Lipschitz Learning, Regularization and Stability, Stochastic Learning, Subgradients

BITS F454 Bio-Inspired Intelligence: Algorithms and 3 0 3 Applications

Concepts of Nature and Social Systems; Principles of Swarm Intelligence; Particle Swarm Optimization - Convergence, Variations and Comparisons, Applications in Engineering; Ant Colony Optimization Algorithms, ACO for NP-Hard Problems; Bio-inspired Models (Bat, Fish, Cuckoo, Bee, Wolf) - Algorithms, Applications, Algorithm Analysis; Study on Search Spaces and Test Functions

BITS F455 Analytics For Supply Chain 3 0 3

Supply chain performance, Descriptive analytics, Supply chain forecasting, studying holt, winter and ARIMA models, Supply chain segmentation. Single period and multi-period inventory modeling, Multi-echelon inventory models, Network flow models, Distribution planning, Sales, & Operations planning, Vehicle routing problems, Simulation in supply chain risk assessment.

Equivalent: MPBA G520: Analytics For Supply Chain

BITS F456 Capstone Project I 3*

This course is the first half of a research and development (R&D) project that comprises two sequential courses (Part A and Part B) and is the capstone for all engineering programmes offered under BITS RMIT Academy. In this culminating academic experience student will apply their technical knowledge and further develop their research, design and professional engineering skills. The authentic project maybe industry based and focuses on producing well-managed practical and pertinent solutions to either discipline specific, or cross disciplinary engineering problems, through robust research and established engineering design processes. The Capstone Project I focuses on: articulation of the project requirements, challenge, need, problem or feasibility; establishment of design criteria and constraints; project planning; the critical appraisal of all the relevant published material by way of a comprehensive literature search and review; benchmarking of all related and relevant solutions; and hence well-informed consideration of possible solutions. After successfully passing this course, students will undertake the required companion course "Capstone Project II" which will result in the fulfilment of the final project deliverable.

Equivalent: OENG1167 Engineering Capstone Project Part A offered at RMIT.

BITS F457 Capstone Project II 4*

This course includes a work integrated learning experience in which student's knowledge and skills will be applied and assessed in a real or simulated workplace context, and where feedback from industry and/or community is integral to their experience. This second half of the Capstone engineering research and development (R&D) project concludes a culminating experience that applies student's technical knowledge, research, design and professional engineering skills. It maybe industry based and aims to produce a well-managed practical and pertinent solution to either discipline specific, or cross disciplinary engineering problems, through robust research and established engineering design processes. This second part of the project (Part B) focuses on: Summarising the outcomes from student's 'Capstone Project I'; Clearly articulating a plan, including milestones and responsibilities; The application of a methodical design process for the systemic optimisation and embodiment of an engineered solution; The manufacture of a tangible deliverable (wherever appropriate); The test and verification of the solution; and a comprehensive suite of relevant project documentation.

Prerequisite: BITS F456 Capstone Project I

Equivalent: OENG1168 Engineering Capstone Project Part B offered at RMIT.

BITS F458 Professional Practice and Ethics 3 0 3

Comprehensive exploration of the ethical, legal, and business aspects of the architectural profession, professional ethics, regulations, contracts, project management, financial considerations,

and legal obligations, case studies, real-world scenarios, and ethical dilemmas, enabling them to make informed decisions, uphold professional standards, and navigate the complex business and legal landscape of architecture, sustainable design practices, social responsibility, and the role of architects in addressing contemporary societal and environmental challenges. strong ethical foundation and a comprehensive understanding of the practical aspects of architectural practice.

BITS F459 Computer Vision 3 1 4

Introduction to digital image format and camera model with calibration; Image features and its use in classification and segmentation; Multiview geometry, Optical flow and Structure From Motion; Introduction to machine learning for computer vision - Image classification with linear classifiers, regularisation and optimisation, evolution of handcrafted feature and classical machine learning models to Convolutional Neural Network (CNN) and deep learning; Various deep learning models for multiple tasks: CNN (classification), Deconvolutional Network (segmentation), Recurrent Neural Networks with LSTM (Long Short Term Memory) and GRU (Gated Recurrent Unit) for video analysis, Attention and Transformers for image and video, Self supervised learning, Generative models, 3D vision.

BITS F461 Software Engineering 4*

Software engineering concepts and methodology; formal requirements specification; estimation; software project planning; detailed design; techniques of design; productivity; documentation; programming languages styles, code review; tool, integration and validation; software quality assurance; software maintenance; metrics, automated tools in software engineering.

BITS F462 Renewable Energy 3

Introduction of renewable energy, advantages, potential, status of development, broad details of different renewable energy systems such as solar, wind, biomass, microhydel, geothermal etc; Renewable energy development policy, Renewable energy industries, international co-operation, HRD and career growth opportunities, consultancy areas and future thrust areas in renewable energy development.

BITS F463 Cryptography 3 0 3

Objectives of cryptography; ciphers – block and stream; mathematical foundations – modular arithmetic, finite fields, discrete logarithm, primality algorithms; RSA; digital signatures; interactive proofs; zero-knowledge proofs; probabilistic algorithms; pseudo-randomness.

BITS F464 Machine Learning 3 0 3

Neural networks; neuro-computing theory and applications, knowledge representation; computational learning theory; statistical/probabilistic methods, genetic algorithms; in ductive/analytic/reinforcement learning and bayesian networks; selected topics such as alpha-beta pruning in game trees, computer models of mathematical reasoning, natural language understanding and philosophical implications.

BITS F465 Enterprise Computing 3 0 3

Overview of enterprise applications and their architecture-Building distributed multi tier applications using enterprise java-Packaging and deploying enterprise applications into application servers- Development of web applications using java servlets -java server pages and java server faces - Usage of JDBC for database driven enterprise applications -Enterprise java support for building soap and Rest enabled web services-Enterprise application integration using software components -Enterprise java beans-Message based communication between enterprise application components using JMS-Need for handling data persistence in database driven applications in an object-oriented manner -Usage of java persistence API for handling data persistence-Need for security of enterprise applications-Securing enterprise java applications using java based Glassfish application server-Configuring glassfish server for SSL security-Working with Realms, Users, Groups, and Role for client authentication-Overview of dot net framework for building distributed enterprise applications-Dot

net framework: windows presentation foundation windows communication foundation-asp.net and ado.net

BITS F466 Service Oriented Computing 3 1 4

Introduction to Web Services: Distributed computing using software component technologies like DCOM and EJBs-overview about Service Oriented Architecture- RPC and Document centric SOAP enabled web services-Describing information using XML - SAX and DOM based XML parsers-XSLT-XPath. SOAP Protocol for web services- Describing Web Services using WSDL-Publishing and Finding web services using UDDI Registry-UDDI SOAP APIs-Inquiry APIs-Publisher APIs. Web Services security -Need for secured web service-confidentiality of web service invocation using XML encryption and its advantages over SSL security -Integrity of soap message using xml digital signing-Maintaining confidentiality and integration together for soap messages -Authentication mechanisms for Web service client – Security Assertion Markup Language- Incorporating saml assertions for web service client authentication- IP layer security for web service-Need for work flow of web services-Usage of Business Process Execution Language for describing workflow of web services- Rest web service, its protocol and usage-Usage of Ajax in invoking Rest web service-Role played by web services in cloud computing.

BITS F467 Bioethics and Biosafety 3 1 4

Introduction to the need and issues governing biosafety, legal, ethical and social implications of human gene manipulation, guidelines for research in transgenic organisms and plants, socio-economic impacts of biotechnological experiments, GLP and MGP and CPCSEA guidelines, patent processing, ethics in stem cell research, animal cloning and organ transplants, environmental pollution-hazards and control, public education and participation in biosafety.

BITS F468 New Venture Creation 3 0 3

Entrepreneurship as career option, idea to opportunity – market analysis and segmentation, presenting a pitch deck, building the startup team, competition analysis, lean startups, product development, intellectual property, sales and marketing, business models, financing, launching a business, growth and exit strategy, social entrepreneurship, business plan presentation skills.

BITS F469 Financing Infrastructure Projects 3 0 3

Investment decisions in infrastructural projects: benefit cost analysis, measurement problems, indirect estimation methods of benefits; Cost of capital: private and public money, different schools of thought on social capital- cases; Multiple projects and constraints: linear and integer programming models, goal programming formulation; Financing infrastructure projects: venture capital, sources of capital-private and public participation, modes of cooperation such as BOOT and BOT national and international sources, international agencies, borrowing terms and conditionalities; Public policy issues, leasing and mortgaging, evaluation issues, infrastructural mutual funds, valuation aspects; Real options, value of option for delay, abandonment and vacant land – judgmental assessment of options; post review and administrative issues in project management, international (cross country) projects, implementation issues.

BITS F474 Rural Infrastructure Planning 3 0 3

Local level government structure; planning methodology and budgeting; regional economics; link of rural infrastructure with poverty alleviation and employment creation; sustainable livelihood approach; participatory planning; Integrated Rural Accessibility Planning (IRAP): need based approach, planning objectives, access needs, questionnaire preparation and data collection, quantification of accessibility, identification of problems and their prioritization, identification, screening and ranking of projects, selection of project and its location, action plan for implementation; Introduction to software such as: HDM (Highway Development and Management System) and RED (Road Economic Decision Model) etc.

BITS F482 Creating and Leading Entrepreneurial Organizations 3 0 3

Fundamentals of entrepreneurship; elements of leadership; identifying business opportunities; market study and research; business plans; finance, issues in raising finance; venture capitalist evaluation of business plans, technical aspects for the project, corporate strategies for growth; legal aspect to entrepreneurship, people skills, marketing and branding; creativity and communication.

BITS F488 Services Management Systems 3 0 3

Understanding Services, the Service Sector today, Designing the Service Enterprise, Technological Issues, Structuring Service Operations, Processes Management, Staffing for Services, Functions of Services Management System, Client Relationships, Measuring and Reporting Services.

BITS F489 Enterprise Resource Planning 3 0 3

Introduction to ERP; Re-engineering and ERP systems; ERP planning, design, and implementation; ERP systems – sales and marketing; ERP systems – accounting and finance; ERP systems – production and materials management; ERP systems – human resources; Managing and ERP project; Supply chain management and e-Market place.

BITS F493 Business Analysis and Valuation 3 0 3

Theory of finance, value maximization, stakeholder theory, and corporate objective function: value creation – ways and means, business analysis: The techniques of strategy and competitive analysis, value chain analysis for competitive advantages, business valuation – approaches and methods, the dark side of valuation: strategic investment decisions.

BITS F494 Environmental Impact Assessment 3 1 4

Environment and global problems; Framing Environmental issues; effects of infrastructure development on environment; prediction and assessment of environmental impacts of infrastructure projects: technical and procedural aspects, guidelines and legal aspects of environmental protection, impacts on air, water, soil and noise environment, valuation, strategic assessment, mathematical modeling for environmental processes; social impact assessment (SIA), dislocation/disruption impact of Infrastructure projects; Life Cycle Assessments (LCA) and risk analysis methodologies; mitigation of environmental impacts; case studies; environmental management plan (EMP), national and international certification and guidelines including ISO.

BITS G501 Biostatistics 5

Methods of collection and presentation of statistical data; calculation and interpretation of various measures like mean, median, mode, standard deviation, kurtosis, correlation coefficient; probability distributions; sampling and estimation of parameters; tests of hypothesis; data analysis. Introduction to data classification, analysis and probability; statistical inference – estimation and hypothesis testing; linear regression and correlation; design of experiments; analysis of variance; non parametric procedures & tests; experimental design in clinical trials and validation; basic techniques in optimization.

BITS G511 Advanced Project 5

This course is designed to permit treatment of an advanced area in a discipline or interdisciplinary pursuit to meet the objectives of acquisition of additional competence by the student and also development of new areas of study or lab. The course will be characterized by minimum formal contact and maximum self-study under immediate supervision by the teacher.

BITS G512 Object Oriented Programming 2 2 4

Basics of object oriented programming: objects, classes, instances; inheritance; polymorphism; operator overloading; static and dynamic binding; small talk, C++, cases from other object oriented languages like Ada, Loop, Flavors, Objective-C, etc.; object oriented software engineering.

BITS G513 Study in Advanced Topics 5

In this course students will be assigned study work in advanced areas of professional interest. Each student will work under the overall supervision and guidance of a faculty member and will in the end submit a project report encompassing critical review of the material studied.

The organisation and evaluation of the course would be achieved through seminars, group discussions, project report etc. The course will be conducted by the team of teachers who provide guidance for study work.

BITS G514 Environmental Health 3 0 3

Environmental Health and its importance, water pollution, air pollution, automobile pollution, pollution due to chemicals used in agricultural sector, handling and disposal of domestic and industrial refuse, incineration of waste materials, techniques for studying, monitoring and controlling pollution, effect on health, vector control, effect of high frequency electromagnetic radiation, nuclear radiation, hazardous wastes, occupational health.

BITS G515 Management Principles and Practices 4*

Management concepts and functions; Decision process; Marketing variables, analysis and research; Services marketing; Financial transactions and statements; Financial planning and control; Manpower planning and development; Personnel appraisal, General administration.

BITS G516 Introduction to Business Sustainability 3 0 3

Evolution of the Concept of sustainable development, Dimensions of sustainable development, Issues and Trends in business sustainability, Business Sustainability, Sustainable Consumption and Production, Industrial Environment Management, Finance of sustainability, Setting Goals and Measuring Progress towards sustainability

BITS G517 Cross Cultural Management 3 0 3

The Critical Role of Culture in Management, The Various Dimensions of Culture, The Impact of Culture On Management Functions Like Communication, Negotiation, Motivation, Leadership and Human Resource Management, Formulating and Implementing Strategy for International and Global Operations, Managing Global Teams, International Assignment and Expatriate Management, Skills and Competencies for Global Managers, International Business Etiquette and Uniqueness of Indian Culture and Management.

BITS G518 Writing Seminar 3 2 5

Understanding claims structures; multiple rhetorical contexts and diverse persuasion strategies in classical, Rogerian and the Toulminian framework; Analyzing arguments rhetorically; Analyzing visual arguments, overview of anthology of arguments, re-evaluating sources and presenting new operational definitions; Project

BITS G521 Fourth Generation Languages and Applications 1 3 4

Nature of 4GLs; application generators; RDBMS and 4GLs; SQL based 4GLs; 4GLs and development of information systems and decision support systems; other types of 4GLs; case studies.

BITS G522 Software Development Standards 1 3 4

Standards and their role in software development; Institutions involved in formulating and promoting standards; operating environment standards; POSIX; software design standards; diagramming standards; coding standards; language design, code generation and usage standards; software portability and standards; standards in software development tools; standards in compilers and interpreters; open systems; OSI; user interface standards.

BITS G524 Health Economics and Policy I 5*

Introduction to health economics; utility and health; how to think about health and health care; the production of health; health through the life cycle; a model of consumption and health; the demand for medical care: conceptual framework; empirical studies of medical care demand and applications; the physician and

the physician-firm; physicians in the marketplace; the hospital as a supplier of medical care; hospitals in the marketplace; the demand for health insurance; government provision of health insurance; externalities in health and medical care; managing the market: regulation, quality certification, and technical change; universal insurance issues and international comparisons of health care systems

BITS G525 Health Economics and Policy II 5*

Health care provision; health in low and middle income countries; health system issues in low and middle income countries; introduction to economic evaluation; making decisions in health care; measuring and valuing effects: health gain; measuring and valuing effects: consumption benefits of health care; cost analysis; using clinical studies as vehicles for economic evaluation; economic evaluation using decision-analytic modelling; characterizing, reporting, and interpreting uncertainty; ethical and social implications of economic evaluations of health policies

BITS G526 Data Sciences I 5*

Different types of data, methods for data collection, organizing, summarizing, and interpretation of data, introducing descriptive statistics (measures of central tendencies, measures of variation), introducing random variables, probability distributions, discrete and continuous probability distributions, sampling, sampling distributions, theory of estimation, estimation of parameters (point and interval estimates), tests of hypothesis, types of errors, determinations of sample size for a study, tests of hypothesis using parametric (t-test, ANOVA) and various nonparametric tests, understand the correlations and regression analysis. An introduction to epidemiologic studies and survival analysis.

BITS G527 Data Science II 5*

Health data mining - importance, opportunities and challenges, basic terminology related to health data science; cleaning and preprocessing health datasets - handling noisy, missing data, data integration, transformation, normalization, feature selection; cluster analysis for health data; classification and prediction for health data - naive bayes, decision trees, ensembles; text mining for health data - analyze unstructured data; time series analysis on health data - analyze and interpret time series data.

(The course Data Sciences II will be part of the coursework requirement for PhD students enrolled into Data Sciences for Global Health PhD programme.)

BITS G529 Research Project I 6

Foundational topics; Introduction to software quality attributes of an AI/ML component (operating cost, latency, updateability, and explainability); Model quality; Architecture of AI enabled systems; Data handling techniques; Testing and checks data quality, data drift, feedback loops; Deployment and MLOps; Introduction to Ethics, fairness, Security and Privacy issues in AI-enabled software.

BITS G539 Research Project II 6

This is a package of two courses dealing with an advanced pursuit in terms of a study project or a lab project in assigned areas of professional interest. Each student will work under the overall supervision and guidance of an assigned teacher. The second course may be a continuation of the task engaged in the first course; or the two courses may be independent of each other. Each course must end with a well-defined project report outlining all the investigative efforts and conclusions.

BITS G540 Research Practice 4*

This course is designed to train the students towards acquiring competence in research methodologies. The course will be conducted in terms of actual participation in Research and Development Work. Each student will be assigned to a faculty member to work on specified projects. The student will be required to present a number of seminars in his research area in a structured manner.

BITS G541 User Interfaces 1 3 4

Emerging importance of user interfaces; user interface management systems; designing UIMS toolkits; hardware and OS aids in

user interface development; human & psychological factors in user interface design; theories, principles and guidelines; emerging interaction styles; menu selection systems, command languages, direct manipulation; interaction device; hypertext; standards in user interface design and implementation; case studies from Domain Dialog; Apple's user interface; Open Look; OSF/Motif.

BITS G553 Real Time Systems

Real time software, Real time operating systems-scheduling, virtual memory issues and file systems, real time data bases, fault tolerance and exception handling techniques, reliability evaluation, data structures and algorithms for real time/embedded systems, programming languages, compilers and run time environment for real time/embedded systems, real time system design, real time communication and security, real time constraints and multi processing and distributed systems.

BITS G554 Data Compression 3 1 4

Introduction: the need for data compression. Information theory and data compression; Entropy, Relative entropy and mutual information. Fano's inequality. Types of information sources, and source extension. Asymptotic equipartition property and data compression. Entropy rates of stochastic processes. Kraft inequality, Prefix codes, Huffman codes and Arithmetic coding. Quantization and Rate distortion theory. Lossy image compression techniques based on DCT, VQ and Fractals. Introduction to wavelets: continuous and discrete wavelet transforms. Filter banks and wavelets. Frames and tight frames. Wavelet packets. Wavelet based signal processing. Joint source and channel coding.

BITS G560 Practice School 20

BITS G561T Dissertation 25 (Max)

BITS G565T Dissertation 5

BITS G612 Methods and Techniques of Systems Engineering 2 3 5

This course would cover various systems engineering methods and techniques in the context of their application to the design, implementation and operation of large, humanly-contrived soft systems. The techniques would be chosen from amongst linear programming, integer programming, queuing theory, inventory control, simulation, maintenance models sampling techniques, forecasting techniques, decision models, network scheduling methods etc. These would be applied in the context of resource planning, facility location, manpower planning, financial management, decision-making, maintenance issues, construction and operation scheduling; planning research issues; social assessment of technology; issues of technology-economy nexus etc.

BITS G613 Systems Analysis for Large Systems 2 3 5

System thinking and approach; concepts of systems with special reference to large, humanly-contrived soft systems; review of mathematical techniques and principles of economics and management required for systems engineering of such systems; modelling and systems engineering methodology for large soft systems.

BITS G619 Professional Practice 2 3 5

This course will aim to achieve a professional development of the student in the context of the overall goal of his/her programme. Depending upon the profession, this course will be conducted in terms of actual participation in professional activities such as teaching, laboratory organization, course development, organizational development, R&D work, design, production, data organization, data preparation or management of institutions/ hospitals/voluntary organizations, etc. The course will also deal with communication aspects such as teaching a course, presenting a paper in the seminar/conference, articulating ideas and concepts to professional audience/customers, etc. This course will also deal with the laws and ethics concerned with the profession of an individual.

BITS G620 Professional Practice I 4

BITS G621 Professional Practice II

These two courses, to be offered in two consecutive semesters, 3 are designed to train the students towards acquiring competence in teaching as well as in research methodologies. The course will be conducted in terms of actual participation in professional activities such as teaching, laboratory organization, course development, R & D work, etc. Each student will be assigned under a faculty member to work on specified projects, and to assist the faculty in teaching and research activities. The student will be required to present a number of seminars in a group in a structured manner.

BITS G624 Computer Based Simulation and Modelling 3

Discrete event simulation on computers; Systems simulation & simulation languages; GASP & GPSS; Continuous simulation - languages and modelling techniques; Forrester's models; case studies.

BITS G629T Dissertation 2 3 5

This is a required component for all higher degree students except for those who opt and are selected for practice school programme. The unit requirements will vary from 12 to 25 units. It may be registered for one full semester (12 to 25 units) after completing all courses or may be registered for varied units (4 to 10 units) along with other courses.

BITS G630T Dissertation 25 (Max)

This is a required component for all higher degree students except for those who opt and are selected for practice school programme. The unit requirements will vary from 12 to 25 units. It may be registered for one full semester (12 to 25 units) after completing all courses or may be registered for varied units (4 to 10 units) along with other courses.

BITS G639 Practice School 25 (Max)

A higher degree student if permitted can register in this course in lieu of Dissertation only after the completion of all course work. Concurrent registration of other courses with this course is not permitted. All clauses of Academic Regulations applicable to First Degree Practice School courses will govern the operation of this course.

BITS G640 Practice School 20

A higher degree student if permitted can register in this course in lieu of Dissertation only after the completion of all course work. Concurrent registration of other course with this course is not permitted. All clauses of Academic Regulations applicable to First Degree Practice School courses will govern the operation of this course.

BITS G641 Management Information and Decision Support Systems 20

Data & information; characteristics of information; components of management information systems; information flows; design and maintenance of management information systems; decision support systems.

BITS G644 Development and Use of Computer Software 2 3 5

Concepts and operations of processors; concept, capabilities and types of software; review and case studies of computer applications. Principles and use of standard software packages. Principles of software creation: processing concepts, flowcharting and algorithms, programming constructs, programming languages, program development sequence. Concepts of data and information: files and databases, logical data storage structures. Information Systems: need, significance, concepts, their Analysis, Design and Implementation. Software Engineering: software life cycle, with special reference to software planning, software requirements and software maintenance. The course would terminate with a term paper on a specialised area of the development and use of computer software.

BITS G649 Reading Course 5

BITS G651 Project Formulation and Preparation 5

This course is designed to inculcate principles of technical documentation as required within S&T organizations. Through this course, students are expected to acquire familiarity with several of the following: Proposals, feasibility reports, formal project reports, short reports, memos, negotiations, contracts, etc. In the process principles of project formulation and evaluation, such as technical considerations; performance specifications; preliminary block diagrams, types and analysis of contracts; cost estimation concepts, work breakdown structure; project data preparation, scheduling facilities etc., would be introduced. The course would invariably include the preparation of a detailed report embodying as many of the above concepts as appropriate.

BITS G654 Advanced Instrumentation Techniques 2 3 5

Generalized approach to measuring systems; performance characteristics of instruments; primary sensing elements and transducers; analog and digital signal conditioning operations; micro-processors in instrumentation; applied process control instrumentation; General purpose and analytical instruments covering spectroscopic, separation, atomic absorption instruments UV-VIS-IR, GLC, HPLC, etc; Instrumentation practices in typical R&D laboratories; instrumentation case studies covering selection, quality assurance, system design, etc; Hands on experience in operation of sophisticated instrumentation systems.

BITS G659 Technical Communication 5

Role and importance of communication; effectiveness in oral and written communication; technical reports; technical proposals; technical descriptions; definitions and classifications; business correspondence; précis writing; memorandum; notices, agenda and minutes; oral communication related to meetings, seminars, conferences, group discussions, etc.; use of modern communication aids.

BITS N101T Physical Fitness, Health and Wellness 3 1 4

Basic Exercise - warm-up and warm-down exercise, Calisthenics and its importance, Cardio-respiratory or endurance exercises - various forms of endurance exercise, exercise with intensity and duration for physical wellness; strength training exercise; various strength exercises and their importance, free hand weight training; flexibility exercise and wellness and relaxation exercise including stretching & yoga. This course can be taken only on audit.

BITS N301T Personality Integration Leadership Orientation and Teamwork 3*

Concept of personality and its role in personal and career growth : self-assessment of strengths and weakness, visioning and goal setting, development of action plans for personal growth; Effective communication, collaboration and conflict management: understanding the process and importance of communication and feedback, assessment of individual conflict management styles, importance of nonverbal communication, creating effective presentations and resume; Leadership and emotional intelligence: understanding individual leadership style, understanding the needs of followers, leveraging the power of EI for relationship building and leading; Team work and networking: building effective teams, decision making and leadership in teams, developing effective networks.

(This course will be offered as an Audit Type course for both First-Degree & Higher-Degree Students)

Civil Engineering

CE F211 Mechanics of Solids 3 0 3

Introduction to mechanics of rigid bodies and deformable bodies, Thermal stresses, Equilibrium of forces, Bending moment and shear force diagrams for determinate beams and frames, Analysis of statically determinate trusses; Flexural and shear Stresses in beams, Combined stresses, Stresses and strains on inclined planes, Introduction to torsion, Torsion in shafts, Slope and deflection in beams due to bending, Introduction to Energy Methods, Stresses in thin cylindrical shells, Suspension cables, Failure theories, Buckling of columns using Euler's Theory.

CE F212 Transport Phenomena**3 0 3**

Concepts and definitions, Fluid pressure and measurement, Hydrostatics, Buoyancy, Fundamentals of fluid flow and Kinematics of Fluid in Motion, Flow Analysis using Control Volume Approach and its applications in conservation of mass, momentum and energy, Analysis of flow through pipes, Differential forms of the fundamental laws, Viscous fluid flow Analysis, Navier-Stokes Equations, Study of Flow pattern through Orifices and Mouthpieces, Notches and Weirs and Dimensional analysis and similitude.

CE F213 Surveying**3 1 4**

Overview of Traditional Surveying Techniques like Chain surveying, Compass surveying and Plane Table Surveying, Traverse Computations and Adjustments, Levelling, Contouring, Curve Setting: Different methods of setting Simple Circular Curve, Compound Curve, Reverse Curve, Trigonometric Levelling, Tachometric Surveying, Surveying with GPS / DGPS and Total Stations and Electronic Distance Measurement, Introduction to aerial photogrammetry.

CE F214 Construction Materials**3 0 3**

Different types of cements, chemical composition, properties and tests, coarse and fine aggregate for concrete, tests on aggregates, grading of aggregates and its effect on concrete properties, chemical and mineral admixtures, properties and tests on fresh and hardened concrete; transportation and placing of concrete, nondestructive testing of concrete, durability of concrete, quality control and acceptance criteria of concrete, Factors in the choice of mix proportions, Proportioning of concrete mixes by various methods – BIS method of mix design.; Special Concretes such as fibre reinforced concrete, high performance concrete, self consolidating concrete etc., Manufacturing/ sources, classification, applications, properties and testing of bricks, blocks, tiles, stones, aggregates, puzzolanas, flyash, lime, wood, timber, paints, tar, bitumen, cutback, emulsion, modified bitumen, steel, non-ferrous metals, polymeric material, geosynthetics, etc. Low cost and waste material in construction. Latest, BIS, IRC & ASTM specifications and guidelines of all above mentioned material, Construction equipments, classification, selection and economics.

CE F230 Civil Engineering Materials**3 2 4**

Different types of cements, chemical composition, properties and tests, coarse and fine aggregate for concrete, tests on aggregates, grading of aggregates and its effect on concrete properties, chemical and mineral admixtures, properties and tests on fresh and hardened concrete; transportation and placing of concrete, non-destructive testing of concrete, durability of concrete, quality control and acceptance criteria of concrete, Factors in the choice of mix proportions, Proportioning of concrete mixes by various methods – BIS method of mix design; Introduction to special concretes. Manufacturing/sources, classification, applications, properties and testing of bricks, blocks, tiles, aggregates, lime, timber, paints, glass, bitumen, cutback, emulsion, modified bitumen, steel, non-ferrous metals, polymeric materials, geosynthetics, etc. Low cost and waste material in construction. Latest, BIS, IRC & ASTM specifications and guidelines of all above mentioned material, and construction equipment.

CE F231 Fluid Mechanics**3 0 3**

Concepts and definitions; compressibility of fluids, Fluid pressure and measurement, Fluid statics, Buoyancy, Rigid body motion, Fluid Kinematics, Conservation laws: Control Volume approach, Differential analysis of fluid flow, Study of flow pattern through Orifices and mouthpieces, Notches and weirs, Analysis of flow through pipes, Viscous fluid flow analysis: Analysis of flow through pipes, Dimensional analysis and similitude.

CE F241 Analysis of Structures**3 0 3**

Static and kinematic Indeterminacy, Energy principles; Force Methods of analysis: strain energy method, consistent deformation method, Displacement Methods of analysis: Slope-deflection method, Moment distribution method; Introduction to Matrix Methods of structural analysis: Flexibility and Stiffness Methods, Influence Line Diagrams; Analysis of Moving/Rolling loads (for determinate structures), Introduction to approximate analysis of

frames and trusses, Analysis of Three-hinged, two-hinged and fixed Arches, Analysis of indeterminate trusses. Exposure to relevant software.

CE F242 Construction Planning and Technology**3 0 3**

Principal components of a building system and their interrelationships, functional planning and requirements of a building and its components using relevant codes, building processes, types and construction of foundation systems, masonry, walls, floors, roofs, vertical transportation, doors, windows, building finishes, plumbing services, damp proofing, temporary supporting structures; introduction to planning and scheduling of projects, construction project network analysis, Introduction to quantity estimation, costing and valuation, contracts, tenders, engineering economy and cost benefit analysis of a project, introduction to building information modeling, computer applications in construction management. Exposure to relevant software.

CE F243 Soil Mechanics**3 1 4**

Introduction, Origin and classification of soils, index properties of soil, Compaction characteristics of different soils, lab and field compaction, quality control, Effective stress principle, capillarity, Darcy's law, permeability, Seepage through soils: piping, quicksand condition, flow nets, flow through dams, filters, Stress in soils due to applied loads, Boussinesq equation, Newmark's Influence Chart, Approximate Method, Compressibility and consolidation characteristics, Consolidation Settlement, Shear Strength and Mohr-Coulomb strength criterion, direct, UCS and triaxial shear tests, strength of loose and dense sands, pore pressures, Skempton's coefficients. Site investigations, methods of drilling, sampling, in situ test - SPT, CPT, plate load and geophysical tests, immediate settlement based on elastic theories and in-situ tests. Exposure to relevant software.

CE F244 Highway Engineering**3 1 4**

Overview of basic characteristics of Transportation systems, social factors and strategic consideration, Road development plans, Highway development projects in India, Road Development organizations, Stages in highway alignment and Detailed project Report preparation, Introduction to transportation planning, Geometric design Standards: Cross section elements, sight distances, horizontal and vertical alignments, Pavement Material Characterization: Aggregate testing and blending, Bitumen and Bituminous Concrete testing and mixture design protocols, introduction to Superpave Mixture Design protocols, IRC methods for the design of flexible and rigid highway pavements, Overview of different stages in flexible and rigid highway construction, Overview of Highway Evaluations and Maintenance, Traffic Engineering: Traffic Characteristics, Highway capacity and level of service concepts, Traffic measurement and analysis, Traffic signals, parking studies and analysis, traffic accidents, Introduction to Intelligent Transportation Systems. Exposure to relevant software.

CE F266 Study Project**3**

These courses include projects which are oriented towards readings from published literature or books about new frontiers of development or analysis of available database. These courses are normally available to students in second or higher levels. These courses must coterminate with project reports.

CE F311 Design of Concrete Structures**3 1 4**

Engineering properties of different concreting materials; Design Philosophies; Concepts of Limit State Method; Limit State Design for flexure of Singly and doubly reinforced rectangular and flanged section beams, one-way and two-way slabs; Design for Bond, anchorage and development length; Design of beams with rectangular and Flanged sections for Shear; Limit state of serviceability for beams and slabs; Limit State Design for collapse of columns subjected to axial, axial plus uni-axial bending and axial and bi-axial bending; Design of Footings; Design of Stair Cases.

CE F312 Hydraulics Engineering**3 1 4**

Behaviour of real fluids: boundary layer theory, turbulent flow through conduits; analysis of closed-conduit hydraulic systems including pipes, valves, fittings, and pumps, water hammer in pipes, pipe networks analysis: Hardy cross method and linear

graph method; Open channel hydraulics: uniform and non-uniform flow; flow past immersed bodies: drag and lift; Analysis of Impact of jets; Introduction to fluid machinery.

CE F313 Foundation Engineering 3 0 3

Earth Pressure theories, Retaining structures, design and checks for stability, General requirement for satisfactory performance of shallow foundations, general, local and punching shear failures, bearing capacity, settlement, tilt and rotation of foundations, proportioning of Shallow Foundations, footings on layered soils and slopes, Deep foundations, capacity of single and group Piles, laterally loaded pile, Stability of slopes, Introduction to Ground Improvement Techniques and geosynthetics with applications, Introduction to machine foundations for different type of machines, Introduction to geotechnical earthquake engineering and liquefaction of soils, computer applications in foundation design.

CE F320 Design of Reinforced Concrete Structures 3 0 3

Design Philosophies: Concepts of working stress in comparison with limit state method; Limit state design for flexure of Singly and doubly reinforced rectangular and flanged section beams; one-way and two-way slabs; Design for bond, anchorage and development length; Design of beams for shear; Limit state of serviceability for beams and slabs; Limit state design for collapse of columns subjected to axial, uni-axial and bi-axial bending; Design of simple footings; Design of simple stair cases.

CE F321 Engineering Hydrology 3 0 3

Introduction to hydrometeorology; Precipitation measurement and analysis; Hydrologic abstractions; Stream flow measurement; Runoff and hydrographs; Floods; flood routing; Ground water hydrology; Sediment transport; Introduction to irrigation engineering, Introduction to dams, spillways, diversion head-works and distribution systems.

CE F323 Introduction to Environmental Engineering 3 0 3

Introduction to environmental systems; Material (conservative and non-conservative systems) and energy balances; Risk Assessment; Water pollution and management; Air pollution and management; Essentials of Solid waste management; environmental noise pollution and its control; radioactive waste management; Modelling of Environmental systems; Introduction to Environmental impact assessment ; Legislations

CE F324 Numerical Analysis 3 0 3

Solution of Linear Algebraic System of Equations, Storage Schemes and techniques to a System of Large number of Equation, Numerical Solutions by Interpolation, Integration of Functions containing Singularities, Finite Element Method, Solutions of Initial and Boundary Value Problems, Boundary Integral Element Method, Solution of Non Linear System of Equations.

CE F325 Fundamentals of Rock Mechanics 3 0 3

Internal structure of Earth; Types of rocks and geological features; Intact rock and rock mass; Shear strength; Rock mass classification systems; Rock slope failure mechanisms; Convergence Confinement Method, Ground and Support Reaction Curves, Longitudinal Deformation Profile, Construction of Metro Tunnels, Cut and Cover Method, Tunnel Boring Machine; Stresses in rocks, Rock burst, Squeezing ground conditions; Methods for improvement of rock mass response.

CE F326 Impact of Climate Change on Water 2 1 3

Introduction to hydrology, climate change, Overview of global climate models (GCM) and Regional Climate Models (RCMs), performance indicators, weights estimation, ranking of GCMs, Ensembling of GCMs; Importance of downscaling, bias correction of data; Role of cluster analysis, fuzzy cluster analysis, Kohonen Neural Networks in the classification of GCMs; Role of Hydrological models; Effect of climate change on the water including urban floods, health and its impacts on society etc.; mitigation and adaptation strategies; Case studies for demonstrating the replicating ability of the employed techniques, limitations, and challenges

CE F341 Hydrology & Water Resources Engineering 3 0 3

Hydrological Cycle and Budget; Precipitation Measurement and Analysis; Hydrologic Abstractions; Stream Flow analysis and concepts of hydrograph; Hydrologic measurements; Statistical analysis in hydrology; Ground Water hydrology; Flood Routing; Water withdrawals and uses, Introduction to dams, spillways, diversion head-works and distribution systems, River basin management, Reservoir planning and multi-purpose reservoirs, hydropower engineering, Systems analysis techniques in planning and practical applications.

CE F342 Water & Waste Water Treatment 3 1 4

Water supply and waste water systems; capacity requirements; analysis of water and waste water; treatment requirements; unit operations and processes of treatment, design of treatment units; disposal of waste water and sludge; design of sewers and water distribution networks; rural sanitation; effluent re-purification and reuse.

CE F343 Design of Steel Structures 3 0 3

Introduction to Limit State Design and Plastic design, Limit state design of bolted and welded connections, Eccentric connection, Design of Tension Members, Design of Compression Members, Design of Beams, Design of plate girders, Column bases. Exposure to relevant software.

CE F345 Computational Geomechanics 3 3 0 3

General Theory of Elasticity; Analysis of Stress and Strain, Spherical and Deviatoric Stress Tensors, General state of stress in three-dimensions in cylindrical coordinate system, Three-dimensional Mohr's stress Circle, Strain Transformation, Octahedral Strains, Mohr's Circle for Strain, Equations of Compatibility for Strain; Pore pressure and stress-strain response of soil due to undrained loading, Volume Change Behaviour, Peak State and Dilatancy, Rowe's Dilatancy Theory; Critical State Parameters, Failure line in p - q space and e - p space, Soil Yielding, Strain Hardening and Strain Softening; Introduction to failure theories of soils, their relative merits and demerits and applicability for different types of soil; Computer Applications; Suitability of the failure models in real-time geotechnical problems.

CE F366 Lab Project 3

CE F367 Lab Project 3

These courses include projects involving laboratory investigation or laboratory development in the students discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

CE F376 Design Project 3

CE F377 Design Project 3

These courses are intended to impart training in design of product/ process or other artifact to the students in the discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

CE F411 Operation Research for Engineers 3 0 3

Linear programming, Simplex method, Duality and sensitivity analysis, Transportation model and its variants, Integer linear programming, Nonlinear programming, Introduction to Multi-objective optimization and case study, Game theory, Evolutionary computation, Inventory models, Queuing system, Decision making under certainty, risk, and uncertainty.

CE F412 Disaster Management 3 0 3

Definitions, types of hazards, natural and man-made disasters, impact, causes and effects, damages, coping mechanism and relief assistance, disaster continuum, preparedness, prevention, mitigation, warning and management, vulnerability assessment, rehabilitation and reconstruction after disasters, pre disaster planning for earthquakes, cyclones, floods, draught and famine, disaster resistant constructions, non-structural and structural mitigation measures, guiding principles of mitigation, education and

training for disasters, disaster case studies, computer use in disaster scenario development.

CE F413 Advanced Structural Design 3 0 3

Design of concrete chimneys, water tanks, retaining walls, bunkers and silos, Design of steel tanks, towers, Roof trusses and Gantry Girder design, Design of plate girders, Design of Beam-Columns.

CE F414 Introduction to Environmental Engineering 3 0 3

Environmental pollution; essentials of solid waste management; environmental noise pollution and its control; water quality significance; air quality management; industrial site selection criteria environmental impact assessment-case studies-computer applications.

CE F415 Design of Prestressed Concrete Structure 3 0 3

Introduction to basic concepts of prestressing; load balancing technique prestressing systems; analysis of prestress; losses in prestress; deflection; design of anchorage zone, design of prestressed concrete girders.

CE F416 Computer Applications in Civil Engineering 3 1 4

The basics and use of recent Civil Engineering Software related to Hydraulics, Structures, Transportation, Geo-technology and Construction Planning and Management etc., Practical assignments on industry related problems using the above software.

CE F417 Applications of Artificial Intelligence in Civil Engineering 3 0 3

Introduction to Artificial Intelligence and soft computing; Neural networks: Introduction, models, and its application in civil engineering, fuzzy logic and its application in decision making, Clustering; Genetic algorithms; Expert systems; Introduction to machine learning (Support Vector Machine), case studies.

CE F419 Geotechnical Earthquake Engineering and Machine Foundation 3 0 3

Seismic hazard, Engineering seismology, Wave propagation, Dynamic Soil Properties, Dynamic bearing capacity, Seismic design of foundation, Seismic slope stability, Dynamic earth pressure, Seismic design of retaining structure, Liquefaction, Design of machine foundation, Soil improvement techniques, Seismic design codes.

CE F420 Introduction to Bridge Engineering 3 0 3

Investigations for bridges, types of bridges and loading standards, selection of bridge type, analysis of culverts and girder bridges, pier and abutments, different types of bridge foundations.

CE F421 Analysis and Design of FRP Reinforced Concrete Structures 3 0 3

Course description is to be developed.

CE F422 Urban Hydrology 2 1 3

Urban hydrology, Hydrological and planning models, Urban flooding: Planning, forecasting and mitigation strategies, General circulation models and downscaling approaches, Management of Syphonic rainwater systems and detention facilities, sustainable urban drainage systems, Impact of anthropogenic activities, case studies.

CE F423 Green Buildings and Energy Conservation 3 0 3

Climate zones and sun path diagram, thermal comfort, heat flow through building materials, energy efficient building design factors like site planning, plan form and orientation, construction techniques, materials and finishes, natural day lighting and ventilation strategies, thermal performance of building elements, Efficient water management in buildings, Green building rating system, Vernacular architecture and its use in contemporary design, Case studies of contemporary green buildings.

CE F425 Airport, Railways and Waterways 3 0 3

Airports: Characteristics of aircrafts related to airport design; runway orientation, length, capacity, configuration and number, taxiway layout, high-speed exit taxiway, terminal building functional areas, visual aids; grading and drainage; Railways: component of railway tracks, train resistance and tractive power, curves and super elevation, switches and crossing, signalling and interlocking, high speed tracks, track stresses. Tunnelling: necessity of tunnels, ventilation, lighting and drainage; Water transportation: nature of water transportation, classes of harbours, desirable features of harbour site, planning and design of port facilities; Pipeline transportation systems: need and planning.

CE F426 Geosynthetics and Reinforced Soil Structure 3 0 3

Geo-synthetics: classification, functions, applications, properties & testing, Applications and advantages of reinforced soil structure. Principles, concepts and mechanism of reinforced soil. Soil-reinforcement interface friction. Behaviour of Reinforced earth walls, basis of wall design, internal and external stability condition, Codal provisions; Seismic design consideration. Bearing capacity improvement and design of foundations resting on reinforced soil; embankments on soft soils; Design of reinforced soil slopes, Indian experiences. Use of geosynthetics for separations, drainage and filtration. Use of geosynthetics in roads, airports and railways, India Road Congress, AASHTO and other relevant guidelines; randomly distributed fiber reinforced soil. Soil nailing. Geocell, PVD, Geosynthetics in Environmental Control: Liners for ponds and canals; covers and liners for landfills – material aspects and stability considerations; Use of jute, coir, natural Geotextiles, waste products such as scrap tire, LDPE and HDPE strips, as reinforcing material.

CE F427 System Modeling and Analysis 3 0 3

Systems and system's approach, Modelling of physical system and non-physical system, Continuous and discrete systems, Time domain analysis, Frequency response, Steady-space analysis.

CE F428 Earthquake Resistant Design and Construction 3 0 3

Earthquake resistant design philosophy. Ground motion characterization, response spectra and design spectra. Free and forced vibration analysis of single and multiple degree of freedom system. Seismic analysis and design of buildings and other structures as per relevant codes. Seismic design of foundations and liquefaction of soil, Earthquake resistant construction and detailing for masonry & concrete structure as per relevant codes.

CE F429 Design of Foundation Systems 3 0 3

Evaluation and interpretation of soil properties, dynamic properties of soil, geophysical and seismic methods, Stress in soil mass due to applied load, various methods of settlement analysis, static and dynamic bearing capacity of footings, bearing capacity of footings resting on layered soils and footing on or near slopes, tilt, rotation and horizontal displacement of foundations subjected to eccentric-inclined loads, foundations on rocks, seismic design of shallow foundations, analysis of raft foundations, circular and annular rafts, structural design of shallow foundations, pile foundations load capacity and settlements, various methods of analysis of laterally loaded Pile Foundations, uplift capacity, piles subjected to dynamic loads, seismic design of pile foundations, structural design of pile foundations, static and dynamic earth pressure theories, stability analysis of retaining walls, reinforced earth wall design, machine foundations for reciprocating machines, impact type, rotary machines such as turbines, turbogenerator, IS code provisions on foundations, codal provisions on structural and earthquake resistant design of foundations.

CE F430 Design of Advanced Concrete Structures 3 0 3

Design of footings and stair cases, Determination of deflection and crack width in beams and slabs, Design of flat slabs, Design of beam column joints, Design of circular Slabs, Design of Retaining walls, Design of beams curved in plan.

CE F431 Principles of Geographical Information Systems- 3 1 4 terms

Introduction to Geographical Information Systems(GIS), Spatial data models, Coordinate systems and geo-referencing, Map projections, Databases and database management systems, Spatial databases, Interpolation methods: Deterministic and Statistical. Digital elevation models and their applications, Network analysis, GNSS, Strategies for development, implementation and management of GIS, Next generation GIS, Case studies on use of GIS from various fields such as water and land resources, environment, transportation; Introduction to remote sensing & Image processing.

CE F432 Structural Dynamics 3 0 3

Free and forced vibrations, single and multi-degree systems, continuous systems, response of various systems to different excitations, damping; numerical evaluation of dynamic response, frequency domain analysis, mode superposition, direct integration for dynamic response.

CE F433 Remote Sensing and Image Processing 3 1 4

Overview, Fundamental concepts of remote sensing, Air photo Interpretation, Multispectral, Thermal and hyper spectral Scanning, Microwave remote sensing, Photographic Systems, Photogrammetry, Digital Image Processing, Image File format, Pre-Processing of Data, Enhancement techniques, Image Transformations, Image classification, Spatial Filtering, Applications.

CE F434 Environmental Impact Assessment 3 0 3

Environment and global problems; Framing Environmental issues; effects of infrastructure development on environment; prediction and assessment of environmental impacts of infrastructure projects: technical and procedural aspects, guidelines and legal aspects of environmental protection, impacts on air, water, soil and noise environment, valuation, strategic assessment, mathematical modeling for environmental processes; social impact assessment (SIA), dislocation/disruption impact of Infrastructure projects; Life Cycle Assessments (LCA) and risk analysis methodologies; mitigation of environmental impacts; case studies; environmental management plan (EMP), national and international certification and guidelines including ISO.

CE F435 Introduction to Finite Element Methods 3 0 3

Element properties, Isoparametric formulations, analysis of framed structures, plane stress, plane strain, and axisymmetric problems, analysis of plate bending, FEM Software applications in Civil Engineering, Introduction to FEM programming. Exposure to relevant software.

CE F491 Special Project 3

This is an unstructured open-ended course where under the overall supervision of an instructor-in-charge, batches of students will be attached to different instructors. Each batch will work on a specific time-bound project which is of basic or peripheral concern of his discipline. Each student must submit a project report as a culmination of his endeavour and investigation. The instructor-in-charge will determine the choice of the project and also whether or not the project report is to be submitted jointly by a group or individually by a student. The course will aim to evaluate student's actual ability to use the fundamentals of knowledge and to meet new unknown situations as demonstrated by the students' interaction with the instructors and instructor-in-charge and aggregated in the project report. The instructor-in-charge may assign specific hours for formal brain-storming sessions.

CE G511 Matrix Methods in Civil Engineering 3 2 5

Matrix techniques; basic equations of solid mechanics; variational methods; finite difference and finite element methods; applications to structural mechanics, soil and rock mechanics, fluid mechanics, and hydraulic structures.

CE G512 Topics in Environmental Engineering 3 1 4

Collection and disposal of solid wastes; air pollution and control; stream sanitation; rural water supply and sanitation.

CE G513 Advanced Computational Techniques 3 1 4

Interpolation, Polynomial Interpolation, Lagrange, Newton's Interpolation, Numerical integration, Wilson θ Method, Newmark's Method, Gauss and Hermitian Quadrature, Quadrature rules for multiple integrals, Large system of linear simultaneous equations, Direct and iterative algorithms based on Gauss elimination, Gauss Seidel method and symmetric banded equations, storage schemes – skyline, band solver, frontal solver, Cholesky decomposition, Non-linear system of equations, Eigen value problems, Forward iteration, Inverse iteration, Jacobi, Given's method, Transformation of generalized Eigen value problem to standard form, Vector iteration method, Initial and boundary value problems, Solution of first and second order differential equations using Euler, modified Euler, and Runge-Kutta methods, Finite difference operators.

CE G514 Structural Optimization 3 1 4

Introduction, Engineering Optimization Problems, Optimal problem formulation, Single-variable optimization algorithms, Bracketing methods, Region Elimination methods, Gradient-based methods, Multivariable optimization algorithms, Evolutionary optimization methods, Simplex Search method, Hooke-Jeeves pattern search method, Powell's conjugate direction method, Cauchy's method, Newton's method, Conjugate Gradient method, Constrained Optimization algorithms, Kuhn-Tucker conditions, Transformation methods, Direct search for constrained minimization, Feasible Direction Method, Specialized algorithms, Integer Programming, Geometric Programming, Nontraditional optimization Algorithms, Genetic algorithms, Simulated Annealing, Structural Optimization, Methods of optimal design of structural elements, minimum weight design of truss members, optimum reinforced design of R.C. C. Slabs and beams, Optimization to the design of structures such as multi-storey buildings, water tank, shell roofs, folded plates.

CE G515 Fundamentals of Systems Engineering 3 1 4

Linear Programming, Queuing Theory, Inventory Control, Simulation, Maintenance models sampling techniques, Forecasting techniques, Decision models, Network scheduling, application to Resources planning, financial Management, facility location, decision making Maintenance issues, construction & operational issues for Civil Engg. System

CE G516 Multicriteria Analysis in Engineering 3 1 4

Introduction, Conventional optimization, Multi-objective Optimization, Fuzzy logic and its extensions, in multi-objective optimization, Multicriterion Decision Making, Deterministic analysis, Stochastic analysis, Fuzzy analysis, Classification problems, Hybrid approaches in Decision Making, Genetic Algorithms, Artificial Intelligence, Artificial Neural networks, Practical applications in Engineering.

CE G517 Waste Management Systems 3 1 4

Introduction, Wastewater and Solid Wastes, Collection and Transportation, Waste Disposal Systems, Land Treatment, Wastewater Management Methods, Wetland and Aquatic Treatment, Landfilling, Incineration, Energy from Wastes, Recycling, Composting, Reduction, Reuse and Recovery, Risk management, Case studies.

CE G518 Pavement Analysis and Design 3 1 4

Basic concepts in transportation planning, accessibility and mobility, land use interaction, government role in transportation planning. characteristics of travel and transport problems, transportation survey and data collection: planning, design and implementation, travel analysis zone (TAZ) development, traditional four-step modelling process, analysis of travel behaviour and demand: studying travel behaviour, analysing urban travel markets; innovations in transportation modelling: travel behaviour model, activity-based models. Econometric modelling using r-studio, modelling travel demand with CUBE. Transportation Demand Management (TDM), Transportation System Management (TSM), and Smart City Transportation Planning: Transit-Oriented Development (TOD), Pedestrian-Oriented Development, liveable street planning, multimodal transportation planning, shared mo-

bility concepts, integrated transportation management and planning. Transportation & energy, climate change, fuel choice and green mobility.

CE G520 Infrastructure Planning and Management 3 1 4

The goals and perspectives of planning; forecasting and design of alternatives; plan testing: economic, financial and environmental evaluation; the challenges of managing infrastructure; Information management and decision support system; Concepts of total quality management; Economics: life-cycle analysis and maintenance, Rehabilitation and Reconstruction (M.R & R) programming; Infrastructure management system (IMS) development and implementation; Rural Infrastructure Planning.

CE G521 Topics in Structural Engineering 3 2 5

Introduction to structural optimization, application to simple structures such as trusses, and simple frames; Theory of plates and its applications in Civil Engineering; folded plate design; theory and design of shell structures specifically with application in structures covering large area.

CE G522 Pavement Design, Maintenance and Management 3 2 5

Materials for road construction: specifications and tests on binder, aggregate and soil; Asphalt mix design; Pavement structure; Stresses in flexible and rigid pavements; Design of flexible and rigid pavements; Pavement Management System (PMS) implementation and operation; Data base requirements; Road condition surveys; Data management; Pavement condition analysis; Determination of maintenance and rehabilitation needs at network level; Panel inspection; Prioritization and optimization; Budgets, programmes and plans of action.

CE G523 Transportation Systems Planning and Management 3 1 4

System and environment; sequential transportation systems planning: trip generation, trip distribution, modal split and traffic assignment. Transportation Systems Management (TSM) actions: traffic management techniques for improving vehicular flow, preferential treatment for high occupancy modes, demand management technique for reduced traffic demand, staggered hours, vehicle restrictions; planning for pedestrians, parking planning; Methods of accident data collection and analysis.

CE G524 Urban Mass Transit Planning, Operations and Management 3 1 4

Modes of public transportation and application of each to urban travel needs; Comparison of transit modes and selection of technology and transit service; Estimating demand in transit planning studies and functional design of transit routes; Terminal design; Management and operation of transit systems, Model for operational management; Fleet and crew management; Terminal management; Fiscal management.

CE G525 Water Resources Planning and Management 3 1 4

Introduction; Quantitative and qualitative assessment of water resources; Engineering principles applied to the management of water resources; Hydrographic and project surveys; Watershed management; Measurement techniques in water resources engineering; Gains of water resources planning to the society; Water economics; Computer utilization areas; Project discussions; Laboratory experiments.

CE G526 Systems Approach to Water Resources Modeling 3 1 4

Introduction to system analysis; Water management models: types and significance; Fundamentals of model development; Model solution techniques (computational methods) such as computer aided optimization, simulation, statistical analysis and reliability considerations; Model calibration and verification; Modeling of water quality subsystems and water quantity subsystems in various water bodies and its methods of analysis.

CE G527 Construction Management 3 1 4

Industry profile, parties involved, contracts, bonds, bidding, changes, pre-planning, construction management approach and

partnering; Planning and scheduling, net-work based scheduling systems (CPM), Resource management, Network acceleration, PERT probabilistic approach.

CE G528 Selection of Construction Equipment and Modeling 3 1 4

Selection and application of construction and earth moving equipment; Productivity analysis of equipment operations; mathematical models for construction operations; Quality issues in construction process modeling.

CE G529 Construction Project Control Systems 3 1 4

Concepts, planning and organization; bar charts and schedule networks; CPM computer software, Resource management; Optimal project duration; Project estimates; Budgeting and cash flow; Project control; PERT and line of balance; Project simulation; Materials management and information systems; Claims; Corrective actions; Total quality management; Equipment economics; Nature of design projects: (1) design of project scheduling networks, (2) design of construction operations, (3) development of project breakdown structure, and (4) development of project cash flow design.

CE G530 Design of Construction Operations 3 1 4

Techniques for the design and analysis of construction operations to maximize productivity and minimize resource idleness; Queuing theory, line of balance, simulation, probabilistic and statistical methods applied to construction; An actual construction operation will be modeled and analyzed as part of the course in the context of a term project.

CE G531 Environmental Conservation 3 1 4

Environmental management; impact of development schemes; essentials of an environmental policy and an environmental act; environmental issues and priorities, ecological effects of current development process; energy resources and water resources planning; Economics of pollution control; National conservation strategy; Organisations dealing with environmental conservations.

CE G532 Advanced Soil Mechanics 3 1 4

Modern concept of soil structure and its application in explaining its behaviour; effects of seepage on equilibrium of ideal soil; mechanics of drainage; theories of elastic subgrade reaction; theories of semi infinite elastic soils; vibration problems.

CE G533 Advanced Composite Materials for Structures 3 1 4

Introduction and History of FRP, Overview of Composite materials, Physical and Mechanical Properties and Test methods, Design of RC Structures reinforced with FRP Bars, Flexural Strengthening of RC Beams, Shear Strengthening of Beams, Flexural Strengthening of Slabs, Strengthening of Axially and Eccentrically Loaded Columns, Seismic Retrofit of Columns.

CE G534 Pavement Material Characterization 3 1 4

Field and Laboratory tests on soil, stabilization techniques. Geosynthetics testing and specifications. Tests on aggregates including the quarrying, crushing, stacking and gradation. Tests on bitumen and importance of viscosity grading, tests on bitumen emulsions and application, tests on modified bitumen. Performance grading of bitumen and the rheology test as per ASTM standards. Bituminous mixture design using Marshall's and Super-Pave methods. Performance tests on bituminous mixtures such as resilient modulus, dynamic modulus, creep tests, 4-point bending fatigue test and Hamburg wheel tracking rutting test. Pavement Quality Concrete (PQC) mixture design and tests on joint filler and sealant materials. Admixtures for bituminous and cement concrete. Alternate materials such as Reclaimed Asphalt Pavement (RAP) material, fly-ash, slags and other marginal materials.

CE G535 Highway Geometric Design 3 1 4

Highway functional classification; route layout and selection, design controls and criteria: turning paths, driver performance, traf-

fic characteristics; highway capacity; access control; safety; environment; Elements of design: sight distance, horizontal alignment, transition curves, super elevation and side friction; vertical alignment: - grades, crest and sag curves; highway cross-sectional elements and their design; at-grade Inter-sections – sight distance consideration and principles of design, canalization, mini roundabouts, layout of roundabouts, inter-changes: major and minor interchanges, entrance and exit ramps, acceleration and deceleration lanes, bicycle and pedestrian facility design; parking layout and design; terminal layout and design.

CE G536 Traffic Engineering and Safety 3 1 4

Road users and their characteristics; traffic studies- volume, speed, origin-destination (O-D) and delay studies; analysis and interpretations of traffic studies; traffic forecasting; capacity and level of service analysis; traffic characteristics at un-signalized and signalized intersections; design of signalized intersections, capacity and LOS of signalized intersections, actuated signal control, signal coordination; traffic controls: signs, markings, street furniture; traffic regulations; parking studies; nature of traffic problems and their solutions; traffic safety: accidents- data collection and analysis; causes and prevention.

CE G537 Transportation Economics and Finance 3 1 4

Need for economic evaluation; concept of total transport cost; fixed and variable costs, elasticity of demand, marginal costs; value of travel time, accident costs; methods of economic evaluation; taxation in road transport, user charges: fees and tolls; highway legislation; investment policies and pricing, issues in financing and subsidy policy, public private partnership (PPP) options in transport sector: BOT, BOOT, BOLT; feasibility studies, identification and sharing of risks in PPP projects, operation and management agreements.

CE G538 Project Planning and Management 3 1 4

Foundations of project management: project life cycle, environment, selection, proposal, scope, ToR standardization; work break down structure; network scheduling: critical path method (CPM), programme evaluation and review technique (PERT), planning and scheduling of activity networks; resource planning: allocation, schedule compression, precedence diagram, generalized activity network; estimation of project cost, earned value analysis, monitoring project progress; quality assurance; contract administration and management; mechanization and advanced process control; quality audit; milestones, bonus and penalties; dispute resolution; capacity building and skill development.

CE G539 Introduction to Discrete Choice Theory 4*

Introduction, element of choice process, individual preferences, behavioral choice rule, utility based choice theory; data collection techniques, stated preference (SP) survey, revealed preference (RP) survey, paradigms of choice data; discrete choice models, property of discrete choice models, Multinomial logit model; overview and structure, Nested logit model formulation; discriminant analysis, Naive Bayes classification, classification trees, classification using nearest neighbors; application of fuzzy logic and artificial neural network in discrete choice modeling.

CE G542 Water Resources and Management 3 1 4

Water resources system for different utilization; theory and analytical methods for minimum cost and optimum development; analysis and design of multi-purpose water resources system; engineering and economic principles applied to the management of water resources.

CE G543 Traffic Flow Theory 3 1 4

Traffic flow elements: speed, volume and density and their relationships; time-space diagrams, controlled access concept, freeway concept, system performances, measures of effectiveness; mathematical modeling; probabilistic & stochastic models of traffic flow process, discrete and continuous modeling: headways, gaps and gap acceptance; macroscopic models; car-following model; queuing models; fundamentals & development of queuing processes; traffic simulation; intelligent transportation systems (ITS).

CE G544 Fracture Mechanics of Concrete Structures 3 1 4

Types of failure, Types of fracture, Modes of fracture, Fracture criteria, Energy release rate, Stress intensity factor (SIF), SIF of more complex cases, Elastic plastic analysis through J-integral, Crack tip opening displacement, Test methods, Fatigue failure, Fracture mechanics of concrete: Need for fracture in concrete, Linear Elastic fracture models, Elasto-plastic fracture models, Nonlinear fracture models, RILEM fracture energy, softening of concrete, fracture process zone, size effect, Interface fracture, Fracture behaviour of special concretes, Numerical analysis.

CE G545 Airport Planning and Design 3 1 4

Air Transport structure and organization; forecasting air travel demand, trend forecasts and analytical methods; air freight demand; airport system; characteristics of the aircraft; airport capacity and configuration; airport master planning: site selection, layout plan, orientation and length of runway as per ICAO specifications; geometric design of runway taxiway and aprons; structural design of runway and taxiway pavements; airfield pavement drainage; airport runway structural evaluation using Heavy Falling Weight Deflectometer (HFWD), overlay design. Passenger terminal function, passenger and baggage flow, analysis of flow through terminals, parking configurations and apron facilities; air cargo facilities-flow through cargo terminals, airport lighting; airport access problem; environmental impact of airports.

CE G546 Highway Construction Practices 3 1 4

Road planning and reconnaissance; right of way selection; fixing of alignment; road construction techniques: construction staking, clearing and grubbing of the road construction area; subgrade construction: excavation and filling, compaction, preparation of sub grade, quality control tests as per MORTH specifications; granular subbase and base course construction: gravel courses, WBM, WMM, stabilized soil subbases, use of geo-textiles and geo-grids; construction of bituminous layers; concrete pavement construction; field quality control ; road making machinery.

CE G547 Pavement Failures, Evaluation and Rehabilitation 3 1 4

Pavement deterioration, distress and different types of failures, pavement surface condition deterioration such as slipperiness, unevenness, rutting, cracking; pot holes, etc., causes, effects, methods of measurement and treatment, use of modern equipment for pavement surface condition measurements, Analysis of data, interpretation. Structural deterioration of pavements: causes, effects, methods of treatment. Structural evaluation of flexible pavements by rebound deflection method, analysis of data, design of overlay, use of FWD and other methods for evaluation of flexible and rigid pavements and their application. Evaluation of new pavement materials, model studies, pavement testing under controlled conditions, accelerated testing and evaluation methods, Test track studies. Instrumentation for pavement testing.

CE G548 Pavement Management Systems 3 1 4

Components of pavement management systems, pavement maintenance measures; pavement performance evaluation: general concepts, serviceability, pavement distress survey systems, performance evaluation and data collection using different equipment; evaluation of pavement distress modeling and safety; pavement performance prediction: concepts, modeling techniques, structural condition deterioration models, mechanistic and empirical models, HDM-IV models, comparison of different deterioration models, functional and structural condition deterioration models; ranking and optimization methodologies: Recent developments, economic optimization of pavement maintenance and rehabilitation.

CE G549 Rural Road Technology 3 1 4

Network planning, accessibility and mobility; road alignment and survey; geometric design: cross-sectional elements, sight distance, horizontal and vertical alignments; road materials and use of marginal materials; pavement design, drainage, culverts and small bridges; construction and specifications; quality control in

construction; pavement failures; maintenance; preparation of detailed project report (DPR); community participation in planning, design, construction and management.

CE G551 Dynamics of structures 3 1 4

Free and forced Vibration Analysis of SDOF system, Response to general dynamic loadings, Numerical evaluation of dynamic response, Effect of damping; Free and forced vibration of undamped and damped multi degree of freedom systems; Modeling for multi degree of freedom systems; Equation of motions, Evaluation of natural frequencies and mode shapes, orthogonality conditions, Modal analysis and modal combination rules, Numerical evaluation of dynamic response for multi degree of freedom, time history analysis; support excited vibration, analysis of non-linear systems, Free and forced vibration analysis of continuous systems, Random vibrations, Stochastic response; Vibration isolation, vibration absorber and tuned mass damper; Evaluation of wind, blast, wave loading and other dynamic forces on structure; Modeling and dynamic analysis of buildings, bridges, water tank, liquid storage tanks, stack like structure, machine foundations etc.

CE G552 Advanced Structural Mechanics and Stability Sta- 3 1 4

Analysis of stress and strain in three dimension domain, deviatoric stress and strain; stress and strain invariants, compatibility conditions, equilibrium equations; stress-strain relations for anisotropic, orthotropic and isotropic elastic materials; yield criterion; plastic potential and flow rules. Problems on plane stress and plain strain conditions, Airy stress function; Axi-symmetric problems; torsion of prismatic bars, circular and non-circular sections; thin-walled sections, membrane and sand-heap analogies, concept of stability of structures and examples of instability. Stability of structures with one and two degree of freedom, buckling of columns; beam-columns and simple frames, lateral torsion buckling of beams; and introduction to postbuckling of plates.

CE G553 Theory of Plates and Shells 3 1 4

Analysis procedure and the basic theory of plates and shells; Different kinds of plates such as rectangular, circular, and elliptical; Different kinds of shell structures such as shell of revolution: spherical shells, cylindrical shells and special shell structures; Principles and applications of bending of plates, membrane theory, bending of shells, and stability of plates and shells; Kirchoff theory, Reissner-Mindlin-Naghadi type theories, rectangular plates-solution by double Fourier series, membrane theory of shells, and case study on plates and shells using numerical tools.

CE G554 Advanced Structural Design 3 1 4

Practical design problems on analysis and design of multistoried and industrial buildings, chimney, retaining wall, water tank, towers, etc using both the steel and concrete materials. Modeling of structures subjected to various load (DL, LL, WL, EQ etc.) combinations, structural analysis, design, and detailing of specific advanced concrete and steel structures.

CE G555 Remote Sensing and GIS in Water Resources 4*

Basic concepts of Remote Sensing (RS) and image processing; photogrammetry; global positioning system and its application in water resources; fundamentals of GIS; map projection; spatial data modeling and analysis; integration of hydrologic models and RS & GIS with relevance to surface and ground water resources. advanced aspects of RS & GIS; case studies.

CE G556 Advanced Computational Hydraulics 4*

Ordinary and partial differential equations; finite difference schemes and their variations, finite element methods and their variations; implicit and explicit types; accuracy, convergence and stability; applications to steady and unsteady flows in various fields in hydraulics; one-, two- and three-dimensional flows; Case Studies.

CE G557 Stochastic Hydrology 4*

Basics of statistics in hydrology, discrete and continuous distributions and their applications to hydrological variables; parameter estimation; hypothesis testing; regression analysis; classification and characteristics of time series; autocorrelation analysis; univariate and multivariate stochastic models; spectral analysis; case studies.

CE G558 Advanced Groundwater Hydrology 4*

Aquifers - hydraulic characteristics of aquifers (confined and unconfined). Basic principles of ground water flow; Techniques of artificial recharge; Well design; groundwater recharge basins and injection wells; flow into aquifer with different boundaries and special cases; ground water models (digital and analog models); groundwater pollution, contaminant transport, remediation and legislation.

CE G559 Soft Computing in Water Resources 4*

Introduction and role of soft computing techniques such as fuzzy logic, expert systems, evolutionary algorithms in water resources engineering; classical sets and fuzzy sets; membership functions; defuzzification; basics of expert systems and relevant terminology; Procedure for development of knowledge base and handling of uncertainty; fundamentals of evolutionary algorithms; case Studies.

CE G560 Hydrologic Simulation Laboratory 4*

Role of simulation and optimization modeling in water resources; data mining techniques in hydrology; database management; applicability of hydraulic and hydrologic related simulation models and softwares; applicability of optimization based models and softwares.

CE G561 Impact of Climate Change on Water Resources Systems 4

Introduction to anthropogenic climate change; impact of climate change on hydrology and water resources; global climate teleconnections; various modeling approaches including general circulation models and downscaling approaches; selection criteria; climate predictability and forecasting; limitations and uncertainties; adaptability to climate change; Case Studies.

CE G562 Advanced Concrete Technology 4

Components of concrete; chemical properties of cement & cementitious paste; heat of hydration; microstructure of cementitious paste; properties of aggregates; chemistry of mineral admixtures; chemistry of chemical admixtures; characterization of powdered and solid block concrete; effect of concrete composition on properties of fresh concrete; rheology of concrete; effect of concrete composition on properties of hardened concrete; shrinkage and creep; correlation between micro- and specimen level properties, interfacial transition zone (ITZ); durability of concrete; prediction of concrete service life; techniques for non-destructive evaluations (NDE) of concrete; green concrete; concrete with alkali activated binders (AAB); difference between alkali-activated binders and blended cements.

CE G563 Stochastic Methods in Civil Engineering 3 1 4

Uncertainty, Discrete and Continuous distributions, Hypothesis testing, Classification and characteristics of time series, Autocorrelation analysis, Multivariate data analysis by logistic regression, discriminant analysis, cluster analysis, factor analysis, queuing theory, Reliability analysis, Statistical quality control, Introduction to univariate and multivariate stochastic models, markov chain and their properties, introduction to Transition probability, case studies.

CE G564 Structural Health Assessment and Rehabilitation 3 1 4

Introduction, Overview of present repair, retrofitting, and strengthening practices, Distress identification, Repair management, Causes of deterioration and durability aspects, Holistic models of Deterioration of RCC, Durability Aspects, Intrinsic and extrinsic causes an stage of Distress, Condition survey and Non-

destructive Evaluation, Classes of Damages and Repair Classification, Structural Analysis and Design, Reserve Strength, Evaluation of Building Configuration, Repair materials and their selection, Rehabilitation and Retrofitting Methods, Analysis and Design of Externally FRP and ECC Strengthened Structures, Retrofitting using External Unbonded Post-tensioning and Near Surface Mounted FRP Rebars, Durability Based Design of FRP Reinforced/Strengthened Bridge Girders, Case Study Problems.

CE G565 Transportation Planning 3 1 4

Basic concepts in transportation planning, accessibility and mobility, land use interaction, government role in transportation planning, characteristics of travel and transport problems; transportation survey and data collection: planning, design and implementation, travel analysis zone (TAZ) development, traditional four-step modelling process; analysis of travel behaviour and demand: studying travel behaviour, analysing urban travel markets; innovations in transportation modelling: travel behaviour model, activity-based models, econometric modelling using R-studio, modelling travel demand with cube, transportation demand management (TDM), transportation system management (TSM), smart city transportation planning: transit-oriented development (TOD), pedestrian-oriented development, liveable street planning, multimodal transportation planning, shared mobility concepts, integrated transportation management and planning, transportation and energy, climate change, fuel choice and green mobility.

CE G566 Public Transportation 3 1 4

Modes of public transportation, history and classification, transit right of way, qualitative swot analysis. role of public and private sectors in mass transit. transit planning and data collection. ridership prediction, route determination, stopping policy, stop spacing determination, transit network design: capacity, way headway, station headway, safety regime, dwell time, frequency. vehicle capacity, transit operation scheduling: development of timetable and determination of fleet size; and, crew scheduling process, demand-based transit planning. fare structure and collection technology. dynamic responsive transit planning. transit system performance measures and benchmarking. innovation in transit system technology

CE G567 Highway Design 3 1 4

Highway functional classification; design controls and criteria: turning paths, traffic characteristics, highway capacity aspects, access control, safety, environment; sight distances; horizontal and vertical alignments; geometric design for expressways, at-grade intersections, roundabouts and mini roundabouts, importance of channelization and design of channelizing islands, intersection layouts; grade separated interchanges: types, layouts, suitability, advantages and limitations of different types of interchanges, performance based design, geometric design consistency; pedestrian-oriented development, liveable streets, bicycle and pedestrian planning; on street and off street parking layouts and design; layouts of truck terminals and bus bays; introduction to geometric design software. plan and profile preparation using drafting and visualization software such as AutoCAD, Micro-station. Alignment design using MXROAD, AutoCAD Civil 3D, open road; checking swept path of turning vehicles: AutoTrack, AutoTurn; Highway design manuals.

CE G568 Traffic Systems Analysis 3 1 4

Characteristics of traffic stream: Traffic flow, speed and density, Traffic data collection. Modeling uninterrupted traffic flow: Microscopic and macroscopic modeling, Car-Following theory. Capacity and level-of-service analysis: Concepts of capacity and level-of-service (LOS) of highways, expressway, highway, multi-lane highway and multi-modal LOS as per latest Highway Capacity Manual (HCM). Traffic flow at Toll-Plazas: Queuing theory, delay and queue length analysis of traffic at Toll-Plazas. Traffic flow at un-signalized intersections: Gap acceptance theory and capacity estimation of traffic at un-signalized intersections. Traffic flow at signalized intersections: Delay and queue length analysis of traffic at signalized intersections, design of signals and concept of Co-ordinated signals. Adaptive signal concepts., Advanced Intelligent Transport Systems (ITS). Introduction to latest Traffic simulation packages, Exposure to relevant codes of practice.

CE G569 Transportation Economics 3 1 4

Introduction to engineering economics. Transportation Demand and Supply. Transportation Cost concept. Conceptual aspects of Elasticity, Demand forecasting methods, factors influencing transport demand, direct and cross-price elasticities of demand, factors that cause shifts in demand function. Investment and financing of transport: Revenue sources; expenditure sources; traditional project delivery methods and innovation in financing. Congestion pricing. Transport project evaluation: economic appraisal; discount rate and time value of money; net present value; cost-benefit analysis and life cycle cost analysis as per IRC:SP:30. Road User Cost Study (RUCS). Feasibility and evaluation, cost, evaluation of alternatives, analysis techniques, measures of land value and consumer benefits from transportation projects, prioritization of projects.

CE G570 Highway Construction Technology 3 1 4

Road planning and reconnaissance; right of way selection; fixing of alignment; road construction techniques: construction staking, clearing and grubbing; subgrade construction: excavation and filling, compaction, preparation of sub grade, quality control tests as per MoRT&H specifications; granular subbase and base course construction: gravel courses, WBM, WMM, stabilized soil subbases, use of geo-textiles and geo-grids; construction of bituminous layers; concrete pavement construction. Hot mix asphalt plants, road construction equipment, material placement and compaction methods, shoulders, highway drainage and roadside requirements; State of the art construction management techniques, construction standards, quality control and quality assurance including contract documents and arbitration.

CE G571 Road Asset Management 3 1 4

Need for Road inventory data, purpose and types. Characterization of pavement performance including the concept of pavement condition index. Application of road roughness data including the calibration for universal roughness standard. The non-destructive measurement of structural condition of the pavement at network and project level. Database Management with automated survey methods for distress prediction. Pavement deterioration models, pavement maintenance and rehabilitation techniques. Life cycle cost analysis using HDM4. Prioritization of pavement maintenance strategies. Developing asset management plans: financial plan, asset valuation, resource allocation. Economic evaluation of alternative pavement design strategy and selection of an optimal maintenance strategy.

CE G572 Transportation Data Analytics 3 1 4

Research Design Concepts in transportation, Data collection and analysis techniques. Probability Distributions, Sampling and Measurement, Interval Estimation, Hypothesis Testing, Analysis of Variance. Simple, Multiple and Time-series Regression, Dynamic Regression Models, Structural Equation Models, Count Data Models. Supervised Learning Methods: Tree-based Methods and Support Vector Machines. Clustering Methods: Dimensionality Reduction (Principal Component Analysis, Independent Component Analysis), Clustering Methods: Hierarchical clustering, K-Means Clustering, Mean Shift Clustering, Density-based Clustering. Data analysis and modelling using R-Studio. Case Studies –Traffic Operations, Pavement Materials and Quality Control, Transportation Planning, Public Transit and Road safety and Highway Geometric Design.

CE G573 Road Safety and Accident Analysis 3 1 4

Road safety, accident statistics and investigation, collision and condition diagrams, accident data collection. Reactive and proactive measures of road safety, safe systems approach, blackspot identification and mitigation measures, development of safety performance functions, road safety audit (RSA), identification and treatment of crash locations, economic analysis of road safety measures, Application of intelligent transportation system in road safety management, Accident investigation, Introduction to Road safety manuals including IRC SP 88, PIARC Documents, AUSTROADS Documents, International Road Assessment Program (I-RAP), Network-based safety analysis, Road signs and markings and related codes, Accident Reconstruction.

CE G574 Pavement Maintenance**3 1 4**

Importance of highway maintenance works and timely rectification of defects in flexible pavements. Routine maintenance, preventive maintenance, periodic maintenance, special maintenance, emergency repairs, patching of potholes, strengthening and rehabilitation of road pavements and drainages. Causes of distress in flexible and rigid pavements, failure of surface and subsurface drainage systems. Maintenance of rural roads: Gravel roads, bituminous roads, cell filled pavements, roller compacted concrete pavement, interconnected block pavement. Maintenance of urban roads: Flexible pavements, thin and ultrathin white topping, cobble roads, interconnected block pavement, side drains and subsurface drainage layer, utility service lines. Retrofitting of dowel bars in rigid pavement.

CE G575 Freight Transportation**3 1 4**

Introduction to Freight System, Overview of three-layer structure of freight: Global, Regional and Local, Freight Transport Industry Structure: Maritime freight Transport, Air freight Transport, Road freight Transport, Rail Freight Transport. Factors affecting freight demand, Freight generation, Freight trip generation, Modelling Inter-Regional Freight Demand Models. Use of GPS and Bluetooth Data for Freight Analysis, International best practices of freight models. Freight Distribution Structures, Logistics Network Planning, Distribution centers, urban freight consolidation centers and warehouses: location, design and operation, Warehouse management and information, Material Management and Inventory Theory, Economic Order Quantity, Demand forecasting for inventory replenishment systems. Off-hour freight delivery (OHD) schemes, Freight emission modelling, Humanitarian Logistics. Relief Network Models for Efficient Disaster Management.

CE G576 Advanced Computational Modelling**3 1 4**

Introduction to computational modelling and simulations for large material deformation or flows; Theoretical basis and programming of grid-based methods and mesh-free/ particle-based methods; XFEM/ SPH/ Peridynamics/ Phase Field approaches etc.; Constitutive modelling; Equation of states; Modelling of real-life problems in structural, soil, rock and fluid mechanics; Techniques for management and visualization of large data.

Pre-requisite: CE F435 OR CE G619 OR ME G512

CE G610 Computer Aided Analysis and Design in Civil Engineering**3 2 5**

Computer languages; CAD, graphics; database management system; knowledge base expert system; development of pre-processor and post processor with graphic interface; analysis and design, optimization techniques, genetic algorithms, software development for analysis and design, interfacing.

CE G611 Computer Aided Analysis and Design**3 2 5**

The course aims at developing complete self reliance in solving analysis & design problems of engineering with the aid of computers. It stresses upon the use of more powerful tools including system planning, simulation and modelling. The student will take up a design project and will work independently on the project guided by the instructor or resource person as and when required. The effort must culminate with a CAAD program and a project report.

CE G612 Advanced steel Structures**3 1 4**

Steel properties; high strength steels, structural behaviour, analysis and design; loads and environmental effects; load and resistant factor design (LRFD); column and beams; connections; member under combined loads; bracing requirements; composite members; plastic analysis and design; tall steel buildings, detailing in steel structures.

CE G613 Advanced concrete Structures**3 1 4**

Materials; high strength concrete, flexure analysis and design; shear and diagonal tension; bond and anchorage; serviceability; torsion; columns; joints; indeterminate beams and frames; yield line analysis; strip method for slabs; composite construction; footing and foundations; concrete building system; concrete tall buildings, detailing in concrete structures.

CE G614 Prestressed Concrete Structures**3 1 4**

Effect of prestressing; source of prestress, prestressing steel; concrete for construction; elastic flexure analysis, flexural strength; partial prestressing; flexural design based on concrete stress limits; tension profile; flexural design based on load balancing; losses due to prestress; shear diagonal tension and web reinforcement; bond stress, transfer and development length, anchorage zone design, deflections.

CE G615 Earthquake Engineering**3 1 4**

Single and multi degree freedom system; seismic risk, causes and effects of earthquakes; seismicity, determination of site characteristics; design earthquakes; earthquake resistant design philosophy; seismic response; earthquake resistant design of structures; detailing for earthquake resistance in concrete and steel structures.

CE G616 Bridge Engineering**3 1 4**

Purpose of bridge; classification of bridges; characteristics of each bridge; loads stresses and combinations; design of RC bridges; design of non-composite and composite bridges; prestressed bridge; continuous spans, box girders, long span bridges; substructure design for bridges.

CE G617 Advanced Structural Analysis**3 1 4**

Flexibility Method; stiffness method; beam curved in plan; two dimensional and three dimensional analysis of structures; shear deformations, shear wall analysis; interactive software development for analysis of structures.

CE G618 Design of Multi-Storey Structures**3 1 4**

Loads and stresses; building frames; framing systems, bracing of multistorey building frames; diaphragms; shear walls and cover; tube structure, approximate analysis and preliminary design; frame analysis; design loading, wind effects and response, earthquake response of structures.

CE G619 Finite element analysis**3 2 5**

Fundamentals of Finite Element Method (FEM); basic formulations of FEM; assembly of elements, solution techniques; 2D and 3D problems; review of the isoparametric elements; thin and thick plate elements; introduction to shell formulations; use of newly developed elements; mixed finite element method; material and geometric nonlinear problems; application of FEM to civil engineering problems, programming FEM.

CE G620 Advanced Foundation Engineering**3 1 4**

Types of foundations, capacity and settlement of foundations, soil properties, design considerations, discrete method for analysis, design of shallow and deep foundations, failure in foundations, remedial measures, case studies of foundations.

CE G621 Fluid Dynamics**3 2 5**

Mechanics of turbulent flow; semi-empirical expressions; statistical concepts; stability theory; flow of non-Newtonian fluids; stationary and moving shock waves; Prandtl-Mayer expressions; two and three dimensional subsonic and supersonic flow; methods of characteristics; small perturbation theory and similarity rules.

CE G622 Soil-Structure-Interaction**3 1 4**

Importance of soil-structure interaction, basic theories, types of interaction problems, numerical modelling, experimental and field investigations, prediction of failure mechanism, economic considerations.

CE G623 Ground Improvement Techniques**3 1 4**

Requirements for ground improvement, various techniques of improvement, water table lowering, ground freezing, electro-osmosis, compaction, tamping, use of explosives, vibratory probes, thermal treatment, addition of lime, cement and bitumen, gravel and sand columns, preloading techniques, reinforced earth, soil replacement techniques.

CE G631 Selected Topics in Soil Mechanics and Geotechnical Engineering 3 1 4

Formation of soil & soil deposits, subsurface exploration, collapsible soils identification treatment & design consideration, review of casting expansion models in soil, treatment of weak soil, numerical modelling, fracture propagation & fracture energy, fluid infiltrated materials, modern trends.

CE G632 Design of Foundations for Dynamic Loads 3 1 4

Evaluation and interpretation of geotechnical reports, selecting foundation design parameters from laboratory and field tests, Selection of foundation, Analysis and design of strip, isolated & combined footing, circular and ring foundation, Design of raft foundation using conventional rigid method, Coefficient of subgrade reaction, Winkler model for footings and mat on elastic foundations, Proportioning and structural design of footings subjected to combined vertical, moment and horizontal loads, Seismic design of shallow foundations, ductile detailing, Analysis and design of different type of pile foundations, piles subjected lateral load, moment and uplift, piles subjected to dynamic loads, design of pile group and pile cap, Seismic design of pile foundations and ductile detailing, Analysis and design of retaining walls, reinforced earth wall design, seismic design of retaining structure, Analysis and design of machine foundations for reciprocating machines, impact type, rotary machines such as turbines, turbo-generator, Computing static and dynamic stiffness of foundations, soil-structure interaction, Optimization and computer aided design of foundation, BIS, IRC, ACI, ASCE, AASTHO and Euro code provisions on structural and earthquake resistant design of foundations.

CE G641 Theory of Elasticity and Plasticity 3 2 5

Basic equations of theory of elasticity; elementary elasticity problems in two and three dimensions; theories of plastic flow; problems in plastic flow of ideally plastic and strain hardening materials; theory of metal forming processes.

Chemical Engineering**CHE F211 Chemical Process Calculations 3 0 3**

Historical overview of Chemical Engineering, Principles of balancing with examples to illustrate differential and integral balances lumped and distributed balances, Material balances in simple systems involving physical changes and chemical reactions, Systems involving recycle, purge and bypass, Properties of substances: single component & multicomponent, single and multiphase systems. Ideal liquid and gaseous mixtures, Energy balance calculations in simple systems, Introduction to Computer aided calculations-steady state material and energy balances for chemical plants

CHE F212 Fluid Mechanics 3 0 3

Dimensions and Units, Velocity and Stress Fields, Viscosity and surface tension, Non-Newtonian flow, Introduction to Fluid Statics, Dimensional Analysis (Buckingham PI theorem), Types of flows, Fluid Statics, Bernoulli equation, Differential and Integral analysis methods of analysis, Navier Stokes equation, Potential flows, Stream functions and velocity potential, Boundary Layer Theory, Flow measurement, Pipe flow analysis, Flow past immersed objects, Packed beds, Fluidized beds, Sedimentation, Pumps and compressors Agitation and Mixing, (Power consumption, mixing times, scale up), Introduction to Turbulent Flows (Reynolds equations), Compressible flows.

CHE F213 Chemical Engineering Thermodynamics 3 0 3

Review of work, heat, reversible and irreversible processes, First Law applications to closed and open systems, Second law, Entropy, and applications related to power and refrigeration, Heat effects, Availability and Exergy analyses Equations of state and generalized correlations for PVT behaviour, Maxwell relations and fluid properties estimation; Residual and excess properties, Partial molar quantities; Gibbs-Duhem Equation, Fugacity and Activity Coefficient models, Vapour-liquid equilibria, Chemical Reaction Equilibrium.

CHE F214 Engineering Chemistry 3 0 3

Organic chemistry – Important functional groups, their reactions and named reactions, Physical chemistry – thermo-physical and thermodynamic properties determination, phase rule, Adsorption equilibria, Electrochemistry, Chemical methods of analysis, Instrumental methods of analysis, Water and waste water chemistry and analysis, Corrosion, Engineering materials and inorganic chemicals, Metals and alloys, Polymers, Fuels and fuel analysis.

CHE F241 Heat Transfer 3 0 3

Steady state and unsteady state conduction, Fourier's law, Concepts of resistance to heat transfer and the heat transfer coefficient. Heat transfer in Cartesian, cylindrical and spherical coordinate systems, Insulation, critical radius, Convective heat transfer in laminar and turbulent boundary layers, Theories of heat transfer and analogy between momentum and heat transfer, Heat transfer by natural convection, Boiling and condensation, Radiation, Heat exchangers: LMTD, epsilon-NTU method, Co-current counter-current and cross flows, NTU – epsilon method for exchanger evaluation.

CHE F242 Numerical Methods for Chemical Engineers 3 0 3

Introduction to mathematical modelling and engineering problem solving, Use of software packages and programming, Errors and approximations including error propagation and Numerical error, Roots of equations: Linear algebraic equations, 1-D and multi-dimensional unconstrained optimization including gradient methods, Linear programming, Non-linear constrained Optimization, Optimization with packages, Least Squares Regression including quantification of error, Polynomial regression, Lagrange, inverse and spline interpolation and Fourier approximation, Engineering applications, Numerical differentiation and integration, Ordinary differential equations, Partial differential equations, Engineering applications

CHE F243 Material Science and Engineering 3 0 3

Introduction on materials for engineering, structures of metals, ceramics and polymers; crystalline structure imperfections; amorphous and semi-crystalline materials (includes glasses, introduction to polymers); Correlation of structure to properties and engineering functions (mechanical, chemical, electrical, magnetic and optical); phase diagrams; Improving properties by controlled solidification, diffusion or heat treatment; Failure analysis and non-destructive testing; Types of materials (includes synthesis, Fabrication and processing of materials): Polymers and composites, Environmental degradation of materials (corrosion); Evolution of materials (functional materials, Biomimetic materials, energy saving materials etc); Criteria for material selection.

CHE F244 Separation Processes I 3 0 3

Molecular diffusion in fluids, Interphase mass transfer, mass transfer coefficient, Theories for interphase mass transfer, overall mass transfer coefficient and correlations, mass transfer with chemical reaction, analogy between momentum, heat and mass transfer, Absorption, Distillation including azeotropic and extractive distillation, Liquid-Liquid extraction, Leaching, Equipment for absorption, distillation, extraction and leaching.

CHE F266 Study Project 3

These courses include projects which are oriented towards readings from published literature or books about new frontiers of development or analysis of available database. These courses are normally available to students in second or higher levels. These courses must coterminate with project reports.

CHE F311 Kinetics and Reactor Design 3 0 3

Kinetics Reaction rate, order, rate constant; Batch reactors Design + basics; Kinetic constants from batch reactor data; Ideal flow reactors Mass and Energy balances; Isothermal, adiabatic and non-isothermal operation; Catalysts, Catalytic rates, Reaction mechanisms; Internal/External transport in catalysts; Non-catalytic solid-gas reactions; Reactor design for ideal flow reactors; Kinetics of Solid Catalyzed Reactions; Yield and Selectivity; Concept of RTD; Segregation and Maximum Mixedness models.

CHE F312 Chemical Engineering Lab I**0 3 3**

This course aims to help students gain practical experience using laboratory-scale experiments to supplement theory courses taught in classroom with major focus on chosen experiments from Fluid Mechanics, Engineering Chemistry, Heat transfer and Separation Processes – 1. Students will collect and analyze experimental data using theoretical principles related to relevant courses already covered in previous Semesters.

CHE F313 Separation Processes II**3 0 3**

Special equilibrium based separations like humidification and water cooling, Drying of wet solids, adsorption, crystallization etc., Mechanical separations like filtration, centrifugation, froth floatation etc., Solid separations based on size reduction including sieving operations and related equipment like crushers, mills, pulverizers etc., special separation processes like ion-exchange, membranes, chromatography etc.

CHE F314 Process Design Principles I**3 0 3**

Process invention using heuristics and analysis (The Design process, Process creation and heuristics for process synthesis, Molecular structure design, Role of process simulators Like Aspen, Chemcad, Hysys etc. in process creation), Detailed process synthesis using algorithmic methods with emphasis on reactor networks, separation trains, batch processes, heat integration etc.

CHE F315 Machine Learning for Chemical Engineers**3 0 3**

Introduction to machine learning and relevance in Chemical Engineering, Univariate and multivariate techniques of data processing; Dimensionality reduction; Machine learning techniques for process modelling; Supervised algorithms (Regression, Artificial Neural Network, Bayes technique, Support Vector Machine etc.); Unsupervised algorithms (Principal component analysis, k-Means Clustering, Hierarchical Clustering, Hidden Markov models etc.); Application to Chemical engineering Problems (reactors, distillation, pumps, heat exchangers etc.) using suitable computational platforms.

Pre-requisite: CHE F242: Numerical Methods for Chemical Engineers **OR** MATH F313: Numerical Analysis

CHE F316 Sustainable Energy Systems**3 0 3**

Concept of Sustainability: Global Overview, Indicators and measurements of sustainability, Sustainability of energy resources, Solar Energy, Wind Energy, Ocean Energy, Nuclear Energy, Geothermal, Hydropower, Hydrogen, Fuel Cells, Energy Storage and Energy Efficiency, Future prospects: Energy consumption Projections, Technology and sector based prospects, Case Studies on recent startup or entrepreneurship ventures on sustainability.

CHE F317 Energy Systems Engineering**3 0 3**

Cradle to grave overview of major current and future energy conversion processes. Energy sources such as coal, natural gas, petroleum, biomass, uranium, wind, and solar. Fuel processing techniques such as FischerTropsch synthesis, gasification, methane reforming, and CO₂ reforming. Power generation technologies including steam turbines, gas turbines, wind turbines, fuel cells, and solar panels. Sustainability impact factors including water consumption, smog formation, and CO₂ emissions. Advanced processing techniques such as combined cycles, turbine/fuel cell hybrids, and CO₂ capture technologies. Real world use and application.

CHE F341 Chemical Engineering Laboratory II**0 3 3**

This course aims to help students gain practical experience using laboratory-scale experiments to supplement theory courses taught in classroom with major focus on chosen experiments from Kinetics and Reactor Design, Process Dynamics and Control and Separation Processes – 2. Students will collect and analyze experimental data using theoretical principles related to relevant courses already covered in previous Semesters.

CHE F342 Process Dynamics and Control**3 0 3**

Introduction to process control, Theoretical models of chemical process, Laplace Transforms, Transfer functions and state space models, Dynamic response of first and second order processes,

Effect of dead time, Dynamics response of more complicated systems, Development of empirical models from empirical data, Feedback control, Control system instrumentation, Overview of Control system design, Dynamic behavior and stability of closed loop system using root locus, frequency response using Bode and Nyquist plots, PID controller design and tuning, Control system design based on frequency response analysis, Feed forward, cascade and ratio control, Introduction to multivariable control system, identification of interaction, design of controllers in interactions, elimination of interactions, Control strategies for common industrial processes such distillation, heat exchangers, etc. Control strategies for Batch processes.

CHE F343 Process Design Principles II**3 0 3**

Review of process synthesis, Design and sizing of equipment of heat exchangers, separation towers, pumps etc. Cost accounting and capital cost estimation, Annual costs, earnings and profitability analysis, optimization of process flow sheets, Steps involved in designing configured industrial systems like solar desalinators, fuel cells, hand warmers etc.

CHE F366 Lab Project**3****CHE F367 Lab Project****3**

These courses include projects involving laboratory investigation or laboratory development in the students discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

CHE F376 Design Project**3****CHE F377 Design Project****3**

These courses are intended to impart training in design of product/ process or other artifact to the students in the discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

CHE F411 Environmental Pollution Control**3 0 3**

Air & water pollutants; sampling and analysis; control methods for air & water pollutants; modeling of different control techniques; advanced wastewater treatment processes; solid waste management, noise pollution; case studies; associated laboratory.

CHE F412 Process Equipment Design**3 0 3**

Application of principles of Chem. Engg. to the selection and design of equipment for Chemical industries; design, cost estimation and selection of process equipment; piping, pressure vessels, heat exchangers, distillation columns etc. Use of computer software packages in the design; plant safety practices; use of codes.

CHE F413 Process Plant Safety**3 0 3**

Role of safety in society. Engineering aspects of process plant safety. Chemical hazards and worker safety. Hazardous properties of chemicals. Safety aspects in site selection and plant layout. Design and inspection of pressure vessels. Storage, handling and transportation of hazardous chemicals. Risk assessment methods. Toxic release, fire and explosions. Boiling liquid expanding vapor explosions. Safety audit. Emergency planning and disaster management. Case studies.

CHE F414 Transport Phenomena**3 0 3**

Analogy for momentum, heat and mass transport; shell balance approach for analysis of individual and simultaneous momentum, heat and mass transport; hydrodynamic and thermal boundary layers; velocity, temperature and concentration distributions in turbulent flow; interphase transport for isothermal and non-isothermal systems.

CHE F415 Molecular and Statistical Thermodynamics**3 0 3**

Fundamental of Statistical Mechanics, Quantum Mechanics, Postulates, Concept of Ensembles, Intermolecular Potential Energy functions; Distribution functions: Radial Distribution Function (RDF); Applications of Statistical Mechanics: Thermo-physical property calculations in ensembles; Cooperative Phenomenon:

Phase Equilibria: Ising model, Gibbs Ensemble (VLE), Thermodynamic Integration, Gibbs-Duhem Integration, Free Energy calculation; Virial EOS: second virial coefficient; Special Applications: From Surface Adsorption: Adsorption Isotherm. Molecular Simulation Techniques: Molecular Dynamics and Monte Carlo Simulation, Monte Carlo Simulation in various Ensemble.

CHE F416 Process Plant Design Project I 3

This course aims to train the student on various aspects involved in design of a process plant. It may be for a Battery limit (B/L) plant or for a Grass roots project. The design will have to be submitted in the form of a standard report. There would be two major submissions: (i) Process selection and PFD, (ii) Material and Energy Balance. This part of the project in conjunction with Process Plant Design Project 2 is a Basic Process Package Report for a complete process plant.

CHE F417 Process Plant Design Project II 3

This course is an extension of Process Plant Design Project 1 and aims to train the student on various aspects involved in design of a process plant. It may be for a Battery limit (B/L) plant or for a Grass roots project. The design will have to be submitted in the form of a standard report. There would be three major submissions in relation to the process selected in Process Plant Design Project 1: (i) Process Design, (ii) Mechanical design, (iii) Costing. This part of the project in conjunction with Process Plant Design Project 1 is part of detailed engineering and economics for a complete process plant.

CHE F418 Modelling and Simulation in Chemical Engineering 3 0 3

Mathematical model and necessity, Introduction to modeling, Physical and Mathematical models, Modelling in Chemical Engineering, Formulation of dynamic models with case studies based on mass, component, momentum and energy balances, Modeling of selected fluid flow, heat transfer, mass transfer and reaction engineering phenomena, Role of Simulation and simulators, Sequential and modular approaches to Process Simulation, Equation solving approach, Decomposition of networks, Convergence promotion, Specific purpose simulation, Introduction to role of evolutionary computation in simulation.

CHE F419 Chemical Process Technology 3 0 3

Process synthesis concepts for flow sheet generation - Unit operations and unit processes, General principles applied in studying a chemical industry; Chemical processes based on agricultural and sylvi-cultural raw materials - Sugar, starch, alcohol, cellulose, etc; Selected technologies for chemicals from inorganic chemical industry covering contact process, fertilizer, chloral-alkali, cement and lime; Natural product industry covering manufacture of oils, soaps, detergents, paper and pulp, Coal and various coal-chemicals, Petroleum and petrochemical products, Raw materials and principles involved in the production of olefins and aromatics, Acetylene, Butadiene and typical intermediates from olefins and aromatics such as ethylene glycol, ethyl benzene, phenol, cumene and DMT/PTA, Dyes and pharmaceuticals.

CHE F421 Biochemical Engineering 3 0 3

Basics of Microbiology and Biochemistry; Introduction to Biochemical engineering, Mass and energy balance in microbial processes; Microbial growth, Substrate utilization and product formation kinetics; Medium and air sterilization; Enzyme kinetics and immobilized enzyme systems; Design of batch, continuous and fed-batch bioreactors; Transport Phenomena in biological reactors; Scale-up principles for biochemical processes; Instrumentation and control of bioprocesses, Bio-separations.

CHE F422 Petroleum Refining Technology 3 0 3

Current world oil and gas scenario; History and development of refining; Petroleum industry in India; Origin, formation, and composition of petroleum; Classification and evaluation of crude oils; Petroleum products and test methods; Crude oil distillation; Thermal, catalytic and finishing processes; Product blending; Lube oil and bitumen (asphalt) manufacturing processes.

CHE F423 Membrane Science and Engineering 3 0 3

Overview of membrane separation processes; Introduction to membranes; Polymeric membranes; Non-polymeric membranes; polymer synthesis; polymer characterization; Metallic membranes; Zeolites; Metal Organic Frameworks; Liquid membranes; Phase inversion; Thermodynamics of Phase inversion; Dip coating; Track etching; Chemical Vapor Deposition; Morphology of membranes; Hydrophilicity; Ultrafiltration; Microfiltration; Nanofiltration; Reverse Osmosis; Pervaporation; Membrane distillation; Gas separation; Biomedical engineering applications; Plate and Frame modules; Spiral wound modules; Hollow fiber membrane-modules; Membrane contactors; Pore diffusion; Solution diffusion mechanism; Mathematical modeling of membrane separation processes; Membrane fouling; Concentration polarization; Cake layer formation; Gellayer formation; Membrane cleaning; Industrial membrane installations; Economics of membrane plants; Opportunities for membrane technology start-up ecosystem.

CHE F424 Rheology of complex fluids 3 0 3

Introduction to complex fluids, origins of non-Newtonian behaviour; fundamentals of rheology; rheological measurements and properties; linear and non-linear viscoelasticity; time-temperature superposition, Boltzmann superposition principle, types of flow fields; various characterization techniques; techniques in oscillatory shear rheology; theoretical models for visco-elastic fluids; Maxwell model, Kelvin-Voigt model, Generalized Maxwell model, Oldroyd model; rheology of dilute polymer solutions, ideal chain conformations, real chain conformations, unentangled polymer dynamics, entangled polymer dynamics; rheology of two phase systems, rheology of soft glassy materials, physical aging and rejuvenation.

CHE F425 Environmental Management Systems 3 0 3

Study of environmental policies, environmental laws, and environmental regulations and permit procedures; ISO series; life cycle analysis; environmental audit; environmental impact assessment, environmental economics, climate change, risk assessment, hazardous waste management, integrating environmental and safety management; case studies.

CHE F433 Corrosion Engineering 3 0 3

Corrosion principles: electrochemical aspects, environmental effects, metallurgical & other aspects; various forms of corrosion. Materials: metals and alloys, non-metallics (polymers and ceramics). Corrosion prevention: materials selection, alternation of environment, design, cathodic and anodic protection, coatings.

CHE F471 Advanced Process Control 3 0 3

Process identification and adaptive control; Model predictive control structures; Model-based control structures; State estimation; Synthesis of control systems-some case studies; intelligent control.

CHE F491 Special Project 3

This is an unstructured open-ended course where under the overall supervision of an instructor-in-charge, batches of students will be attached to different instructors. Each batch will work on a specific time-bound project which is of basic or peripheral concern of his discipline. Each student must submit a project report as a culmination of his endeavour and investigation. The instructor-in-charge will determine the choice of the project and also whether or not the project report is to be submitted jointly by a group or individually by a student. The course will aim to evaluate student's actual ability to use the fundamentals of knowledge and to meet new unknown situations as demonstrated by the students' interaction with the instructors and instructor-in-charge and aggregated in the project report. The instructor-in-charge may assign specific hours for formal brain-storming sessions.

CHE F497 Atomic and Molecular Simulations 3

Particle based simulations at atomic and molecular level. Molecular dynamics (MD), Lyapunov exponent, various algorithms for integrating the equation of motion, Verlet algorithm. Monte Carlo (MC) algorithm, Trial moves, MD and MC in various ensembles, thermostats, barostats etc. Hands-on simulations using

GROMACS or LAMMPS or similar. Free energy calculations and phase equilibria. Various other applications of molecular mechanics calculations. State of the art development in the field, latest force fields, parameterization techniques etc. Introduction to density functional theory (DFT), Hands on simulations using any DFT packages such as ADF or GAUSSIAN or GPAW or VASP or similar.

CHE F498 Colloids and Interface Engineering

Colloids – Intermolecular forces and Properties of the colloids. Interface and Surface active agents – Thermodynamics of interfaces, interfacial rheology and transport process, surface free energy, surface tension, thermodynamics of micelle and mixed micellar formation, electrical phenomena at interfaces. Emulsion, Micro emulsion and Foam – Preparation, mechanism and stabilization, characterization and application of foams. Measurement techniques – Interfacial tension, contact angle, zeta potential and particles size. Industrial applications – Applications of various interfacial phenomena in the industries. Nanomaterials – Application of surface active agent through the surface modification for the synthesis of nanostructured material.

CHE G511 Fluidisation Engineering 3 1 4

Fundamentals, industrial applications; study, design and operation of fluidisation units.

CHE G512 Petroleum Refining and Petro- Chemicals 3 1 4

Origin, formation and composition of petroleum; history and development of refining; refinery products and test methods; classification and evaluation of oil stocks, fractionation of petroleum; thermal and catalytic processes; properties & production of petrochemicals.

CHE G513 Environmental Management Systems 3 2 5

Introduction to air & water pollutants & solid wastes; sampling & analysis techniques; impact of these on environment; national & international regulations; ISO series; conventional & non-conventional energy resources; life cycle analysis; environmental audit; sustainable developments; case studies.

CHE G514 Evolutionary Computation 5

Non-traditional optimization techniques; population based search algorithms; evolutionary strategies; evolutionary programming; simulated annealing; genetic algorithms; differential evolution; different strategies of differential evolution; Memetic algorithms; scatter search; ant colony optimization; self-organizing migrating algorithm; other emerging hybrid evolutionary computation techniques; engineering applications involving highly non-linear processes with many constraints and multi-objective optimization problems.

CHE G521 Chemical Engineering Analysis 2 2 4

Mathematical analysis of chemical engineering problems; introduction to modelling and simulation techniques in the analysis of systems; emphasis on applying mathematical techniques to real Chemical Engineering processes and on physical and mathematical interpretation of results; use of computer software for analysis and solution of mass and energy balances problems for complex processes.

CHE G522 Polymer Technology 3 1 4

Polymerisation techniques; classification of polymers; mechanism and kinetics of formation of polymers; different techniques for determination of different types of molecular weights; polymer structure; definition and measurement of glass transition and crystalline melting temperatures; viscoelasticity and rubber elasticity behaviour; degradation and stability; polymer processing; rheology and applications. The course will terminate with several design projects on real life problems.

CHE G523 Mathematical Methods in Chemical Engineering 3 2 5

An introduction to mathematical modelling and simulation, Fundamentals of functional analysis, Linear algebraic equations and related numerical schemes, ODE's IVP and related numerical schemes, Partial differential equations and related numerical

schemes, Optimization and related numerical schemes, Application of the above principles to solving problems in Chemical Engineering, Role of computer programming and packages in problem solving.

CHE G524 Introduction to Multiphase Flow 3 1 4

Introduction to multiphase flow, Single particle motion, Bubble and droplet transition, Marangoni effects, Bubble growth and collapse, Cavitation, Flow patterns, Internal flow energy conversions, Homogenous flows, Flows with bubble and gas dynamics, Sprays, Granular flows, Drift flux models, System instabilities.

CHE G525 Chemical Process and Equipment Design 3 1 4

The nature and function of process design, Flow sheet preparation and drawing, Process Planning Scheduling and Flow Sheet Design, P and I diagrams, Piping Design, Pump size selection. Design information and data, Specification and design of process equipment, Rules of THUMB for design of equipment, Software use in process design, Process design of equipment in heat and mass transfer, reactors, pumps, etc., Mechanical design of selected equipment.

CHE G526 Nuclear Engineering 3 1 4

Review of Nuclear Physics, Mechanism of nuclear fission, Fission cross section, Fission products, Reactor Physics, Types of nuclear reactors, Construction and control of nuclear reactors, Heat transfer in nuclear reactors, Design and operation, Reactor shielding, Nuclear fuels, Moderators, Coolants, Reflectors and structural materials, Nuclear fuel cycle, Spent fuel characteristics, Reprocessing techniques role of solvent extraction in reprocessing, Reactor control and safety.

CHE G527 Energy Conservation and Management 3 1 4

Energy conservation, Growth and demand of energy, Energy availability, Comparison of specific energy use in select industry, Potential and status of energy in India, Energy saving potential in industries, Potential of energy efficiency in India, Energy available for industrial use and the role of conservation, Energy management and policy, Comprehensive energy conservation planning (CECP), Definition and principles of energy conservation, Energy conservation technologies, Cogeneration concept and scope, Energy audit and management. Energy conservation in utilities.

CHE G528 Introduction to Nano Science and Technology 3 1 4

Introduction to nano-science, Basic idea of solid state physics and quantum mechanics, Quantum wells, Wires and dots, Properties of nanomaterials, Carbon nanotubes, Nanosynthesis, Characterisation methods, Application of nano-materials to various fields like electronics, medical, MEMS, photonics, molecular switches and others, Special reference to Chemical Engineering as in catalysis, heat transfer and special additive and performance materials (nanofluids, nanocomposites), Future of nano science and technology, Large scale manufacture and technological issues.

CHE G529 Pulp and Paper Technology 3 1 4

Selection of pulp and paper making raw materials, Wood Anatomy- identification, Preparation of wood chips, Chip screening, Storage and chip conveying, Chemical composition of fibrous raw materials, Chemical Pulping, Mechanical Pulping, Chemical thermo-mechanical (CTP) processes, Waste Paper Pulping, Bleaching and washing, Chemical Recovery, Description of various grades of pulp & paper, Mechanical and chemical properties of pulp, Paper making, cellulose derivatives- preparation & end use, Environmental aspects in pulp and paper industry.

CHE G531 Project Engineering 2 2 4

Project feasibility studies and report; Project appraisal; Project solution and evaluation; Project planning; Economic decision making; Project preparation and management.

CHE G532 Alternate Energy Resources 3 1 4

The scope and present day technology in utilization of solar energy, wind power, tidal power, geothermal power, M.H.D. and fuel cells.

CHE G533 Petroleum Product Characterization 3 2 5

Methods of estimation of characterization parameters for pure hydrocarbons; methods of characterization of petroleum fractions and products; experimental methods on measurement of basic properties obtained from laboratory testing; methods of prediction of properties for defined mixtures from pure-component properties (normal boiling point, density, molecular weight, critical properties, etc.); methods of prediction of properties for undefined mixtures based on certain bulk properties; characterization methods for light and heavy as well as narrow and wide boiling range mixtures; predictive methods for some characteristics specifically applicable to petroleum fractions that affect the quality of a fuel; standard test methods recommended by ASTM for various properties; minimum laboratory data needed to characterize various fractions as well as analysis of laboratory data and criteria for development of a predictive method; introduction to characterization of crude oils and reservoir fluids; associated Petroleum Laboratory experiments.

CHE G541 Process Plant Simulation 2 2 4

Computer aided analysis of chemical process systems; classification and development of mathematical models to various chemical engineering systems; decomposition of networks; tearing algorithms; numerical methods for convergence promotion and solving chemical engineering problems; traditional & non-traditional optimization techniques; specific purpose simulation; dynamic process plant simulation; case study problems using professional software packages.

CHE G542 Computational Transport Phenomena 3 2 5

Concepts; partial differential equations: types, boundary conditions, finite difference scheme, error analysis, grid generation, stability criteria; conduction and convection : two-dimensional steady state problem, methods for solving coupled algebraic equations, finite element method; fluid flow : governing equations, various approach of simulation (stream-vorticity, primitive variable), staggered grid, similarity solution, Newton-Raphson method, explicit and implicit formulation; solution of Navier-Stokes equations : solution of full and parabolized equations, unsteady flow, MAC, SIMPLE algorithm, RNS method; Mass Transfer : dynamic model, mass transfer with simultaneous convection and diffusion, transient multicomponent diffusion; short projects on development of codes for various real life problems involving transport processes.

CHE G551 Advanced Separation Technology 3 2 5

A brief overview of the existing separation technologies such as adsorption-based separation, membrane separation, cryogenic separation, and biotechnology-based separation. Recent advancements on the above areas and the new concepts such as simulated moving bed adsorption, thermally coupled pressure swing adsorption, reactive distillation, bio-filtration, supercritical fluid extraction etc. This course will terminate with several design projects on real life problems.

CHE G552 Advanced Transport Phenomena 5

Viscosity, thermal conductivity and diffusivity, Shell momentum and energy balance, equations of change for isothermal and non-isothermal systems, Concentration distribution in solids and laminar flows, momentum, thermal and concentration boundary layers near walls, origin of turbulence, length scales in turbulent flows, Reynolds (RANS) equations, estimates of Reynolds stress (k-epsilon and k-omega type models), turbulent shear flow near a wall, turbulent flow in pipes and channels, turbulent heat transfer, Introduction to large eddy simulations models, rheology and material functions, non-Newtonian viscosity and generalized Newtonian models, Linear and non-linear visco-elasticity, radiation heat transfer, multi-component systems, Coupled heat and mass transfer, evaporation, boiling and condensation, chemical reactions, Special topics: Flow through porous media, compressible flows, multiphase flow, Transport phenomena in biochemical systems.

CHE G553 Statistical Thermodynamics 4

Review: Classical thermodynamic and elementary Statistical Mechanics, Macroscopic and microscopic descriptions of the state of

a system, Equilibrium ensembles, the partition function and thermodynamic properties; System of independent particles; Fluctuations and the compressibility equation; Chemical equilibrium in ideal gas mixtures; Molecular based equations of state, SAFT, Lattice statistics; Real gases, Virial equation; The liquid state: lattice models, distribution functions theories, perturbation theories; Liquid mixtures: solution theories and local composition models, Statistical thermodynamics of electrolytes.

CHE G554 Computational Fluid Dynamics 4

Introduction to CFD, Equations of change for momentum, energy and mass transport, introduction to partial differential equations, Numerical analysis and discretization techniques, Managing uncertainties in CFD, grid generation, application of CFD to solve Chemical Engineering problems, Introduction to COMSOL, data analysis, validation and post processing.

CHE G556 Electrochemical Engineering 4

Basic physics of galvanic cells, Electrochemical Energy conversion, Electrochemical Energy storage, Equivalent circuit dynamics, Impedance spectroscopy, Impedance of electrodes, Nernst equation, Fuel cells and batteries, Faradic equations in dilute solutions, Butler Volmer equation, Reactions in concentrated solutions, Ion absorption and intercalation, Concentration polarization, forced convection in fuel cells, Transient diffusion, Warburg impedance, Diffusion in concentrated solutions, Transport in bulk electrolytes, Ion concentration polarization, Double layer structure, Transport on porous media, Porous electrodes, Super capacitors, Electrostatic correlations.

CHE G557 Energy Systems Engineering 4

Cradle to grave overview of major current and future energy conversion processes. Energy sources such as coal, natural gas, petroleum, biomass, uranium, wind, and solar. Fuel processing techniques such as Fischer-Tropsch synthesis, gasification, methane reforming, and CO₂ reforming. Power generation technologies including steam turbines, gas turbines, wind turbines, fuel cells, and solar panels. Sustainability impact factors including water consumption, smog formation, and CO₂ emissions. Advanced processing techniques such as combined cycles, turbine/fuel cell hybrids, and CO₂ capture technologies. Real world use and application.

CHE G558 Chemical Process Optimization 4

Introduction to Process Modelling and simulation, Fundamentals of analytical optimization. Survey of one dimensional line-search methods, and multi-dimensional unconstrained and constrained numerical optimization algorithms. Applications of linear programming, nonlinear programming, mixed integer linear/nonlinear programming, and parameter estimation in chemical engineering. Feasible-path and infeasible-path techniques for chemical process flowsheet optimization, Evolutionary computation in Chemical Engineering.

CHE G559 Reactor Physics and Engineering 5

Nuclear Reactions, Binding Energy, Fission Reactions, Fissile and Fertile Materials, Radioactive Decay; Neutron Cross Sections, Nuclear Fuel Properties, Moderators, Energy Spectra, Infinite Medium Multiplication, Power Reactor Core & Kinetics, Neutron Balance & Diffusion Equation, Four-factor formula, Two-group analysis, criticality equation, Electrical power generation from nuclear fission, fundamental aspects of fission chain reaction, and reactor design. Reactor concepts & types, their static and dynamic characteristics Reactor operation and control, Startup and shut down of systems.

CHE G560 Nuclear Fuel Cycle and Waste Management 5

Processing of nuclear fuel with descriptions of mining, milling, conversion, enrichment, fabrication, irradiation & properties of irradiated fuel, reprocessing, and waste disposal. In-core and out-of-core nuclear fuel management design, Nuclear power plant and fuel cycle economics, Management of spent fuel, high-level waste, uranium mill tailings, low-level waste and decommissioning wastes. Fundamental processes and governing equations for waste management systems, safety assessment of waste disposal facilities, Chemical Engineering operations in Nuclear fuel

manufacture, waste reprocessing operations and waste management, Process Engineering for Nuclear Industry.

CHE G561 Nuclear Reactor Control and Instrumentation 4

Fundamentals of process instrumentation and control, Open and closed loops, SCADA and DDC, PLC, Alarms and Safety interlocks for shutdown and emergency shutdown, special sensors and sensor specifications for Nuclear Industry, Nuclear reactor safety, Special control logic for Nuclear safety, reliability and redundancy, Nucleonics: application of Nuclear materials and radiation in measurement techniques, Nucleonics based instruments for analysis, Design, maintenance and operation of such instruments. Calorimetry, detection of alpha, beta and gamma rays including spectrometry, liquid scintillation counting.

CHE G562 Thermal Hydraulics and Heat Transfer 4

Thermal-hydraulic core design and analysis of nuclear systems, Single and two-phase flow, Flow regimes, pressure drops, frictional losses, pumping power modeling of fluid systems. Design constraints imposed by thermal-hydraulics heat generation, temperature distribution, heat removal, reactor heat sources & coolants, departure from nucleate boiling, boiling heat transfer, critical heat flux conduction in reactor components and fuel elements, heat transfer in reactor fuel bundles and heat exchangers, application of CFD in thermo-hydraulics of core.

CHE G563 Nuclear Chemical Engineering 4

Solvent Extraction, Ion Exchange, Decontamination, Isotope Separation, Unit operations and processes used in the Production of Heavy Water, Desalination, Thermo-chemical Cycle for Hydrogen Production, district heating, nuclear propulsion, waste processing including vitrification.

CHE G564 Nuclear Materials and Radiation Damage 4

Nuclear Materials; fabrication and quality control, non – destructive evaluation and irradiation behavior of uranium, plutonium and thorium based ceramic, metallic and composite fuels; fuel failure, post irradiation examination and mitigation of fuel failure; fabrication, heat treatment, property evaluation and irradiation behavior of fuel cladding and core structural materials e.g. aluminum & alloys for research reactors, zirconium alloys for water cooled nuclear power reactors and stainless steels and oxide dispersion strengthened (ODS) steel for fast reactors; physical, chemical and instrumental methods of analysis of nuclear materials and real time accounting of nuclear materials, radiation damage of nuclear fuels, pressure vessel, pressure tubes and other structural materials including radiation-embrittlement, void swelling, irradiation growth and creep, fracture toughness etc.

CHE G565 Radiation and Radio Isotopes Applications 4

Nuclear non-power research reactors, measurement of radiation and use of neutron radiography, neutron diffraction and activation analysis for materials characterization; Production of Radioisotopes and their applications in medicine and healthcare, food and agriculture including food irradiation & preservation, radiation induced mutation for seed and crop, sterilization and application of radioactive tracers in basic and applied research.

CHE G566 Nuclear Safety, Security and Safeguards 4

Radiation interaction & safety, environmental aspects, internal and external dose evaluation, reactor effluents and release of radioactivity, Operational and maintenance safety, Hazop and Hazan analysis, HSE issues and systems management in Nuclear installations and Nuclear industry and Nuclear Laboratories, Design basis threat (DBT) and threat analysis and evaluation, Detection, delay and response technologies and evaluation, Incorporating insider threat/wrong operation in DBT, Security and safety in Nuclear Materials Transportation, Nuclear forensics and consequence management, Nuclear systems safety and security analysis, Technologies and techniques for securing nuclear materials, Nuclear materials safeguard systems from theft, spillage and other unforeseen incidents, Fuel facility safeguard systems, Design of safeguard systems, Intrinsic and Extrinsic safeguard and proliferation resistance of fissile and fertile materials, Tech-

nical issues associated with Nuclear Non Proliferation, Facility inspection, safety, security and safeguard audit, Elements of non-proliferation policies, treaties and enforcement technologies.

CHE G567 Natural Gas Processing 4

Overview of Natural Gas industry; Overview of Gas Plant processing; Field operation and inlet receiving; Compression; Gas treating; Gas dehydration; Hydrocarbon recovery; Nitrogen rejection; Trace component recovery or removal; Liquids processing; Sulfur recovery; Transportation and storage; Liquefied Natural Gas; Capital cost of Gas processing facilities; Natural gas processing plants.

CHE G568 Modeling and Simulation in Petroleum Refining 4

Introduction to modeling and simulation; Numerical methods and software; Modeling and simulation of multi-component distillation columns; Reactor modeling in the petroleum refining industry; Modeling of catalytic hydro-treating; Modeling of catalytic reforming; Modeling and simulation of fluidized-bed catalytic cracking converters.

CHE G569 Petroleum Production Economics 4

Cash flow analysis in the petroleum industry (definition of cash flow, deriving net cash flow under tax/royalty systems and production sharing contracts, depreciation methods, inflation, sunk costs). Economic indicators (net present value, rate of return and other indicators). Fiscal analysis (the nature of petroleum fiscal regimes, the effects of fiscal regimes on exploration and field development decision making, economic analysis of fiscal regimes in India & abroad).

CHE G611 Computer Aided Analysis and Design 2 3 5

The course aims at developing complete self reliance in solving analysis & design problems of engineering with the aid of computers. It stresses upon the use of more powerful tools including system planning, simulation and modelling. The student will take up a design project and will work independently on the project guided by the instructor or resource person as and when required. The effort must culminate with a CAAD program and a project report.

CHE G613 Advanced Mass Transfer 3 2 5

Use of stage and differential contact concepts in design of mass transfer equipment; methods of determining and interpretation of rate data; multicomponent distillation, absorption and extraction.

CHE G614 Advanced Heat Transfer 3 2 5

Heat conduction with unsteady boundary conditions; recent advances in natural and forced convection; condensation and boiling phenomena; heat transfer in high speed flows; liquid metal heat transfer, radioactive metal heat-transfer between surfaces in absorbing media; complex problems involving simultaneous conduction, convection and radiation.

CHE G615 Advanced Separation Processes 3 2 5

Shortcut and rigorous methods of conventional separation processes such as multicomponent distillation, absorption, stripping and extraction; Azeotropic and Extractive distillation; adsorption based separation, simulated moving bed adsorption, thermally coupled pressure swing adsorption; cryogenic separation, gas liquefaction; membrane based separation, pervaporation, liquid membrane; biotechnology based separation, modeling approach, design considerations, biofiltration; reactive distillation; super critical fluid extraction.

CHE G616 Petroleum Reservoir Engineering 3 2 5

Origin and composition of petroleum; Geographic distribution of oil; Petroleum geology; Exploration, drilling and recovery; Drilling methods and drilling fluids; Lubricants and spotting fluids; Corrosion control; Analytical and test methods; Enhanced oil recovery; Injection fluids; Polymer and caustic flooding; Use of surfactants; Improvement of oil displacement efficiency; Environmental and economic aspects.

CHE G617 Petroleum Refinery Engineering**3 2 5**

History and development of refining; Indian petroleum industry; Composition of petroleum, laboratory tests, refinery products; Classification, characterization and evaluation of crude oil; Trends of petroleum products; Atmospheric and vacuum distillation; Design of crude distillation column; Catalytic cracking; Hydrotreating and Hydrocracking; Catalytic reforming; Delayed coking and visbreaking; Furnace design; Isomerization, alkylation and polymerization; Lube oil manufacturing; Energy conservation in petroleum refineries; Environmental aspects of refining.

CHE G618 Petroleum Downstream Processing**3 2 5**

Petrochemical feedstock; Pyrolysis of Naptha and light hydrocarbons; First generation petrochemicals: Ethylene, Propylene, Butylenes, Acetylene, Butadienes, Chloroprene, cyclohexane, BTX, Polymethyl Benzenes; Second generation petrochemicals: synthesis gas, methanol, ethanol, ethylene oxide, propylene oxide, acetone, allyl alcohol, glycerol, acrylonitrile, Acrylic acid and derivatives, phenol, aniline, nylon monomers, polyester monomers, styrene and other monomers; Third generation petrochemicals: plastics, rubbers, fibres, resins, detergents, pesticides, dyes, protein, explosives, petroleum coke and carbon black; Catalysts in petroleum refining and petrochemicals processes; Transportation of dangerous goods; Health and safety in petrochemical industries; Pollution and toxicity; Future of petrochemicals.

CHE G619 Process Intensification**3 2 5**

A brief review of the process intensification (PI), includes philosophy and principles of PI; equipments and methods for PI; few examples of their application on the commercial scale, such as multifunctional reactors, hybrid processes, monolithic reactors, high gravity reactors etc., industrial practice of PI- methodology and applications; PI by process synthesis; PI by plant safety. This course will terminate with several design projects on real life problems.

CHE G620 Energy Integration Analysis**3 2 5**

Importance and scope of application of Energy Integration; Pinch technology tools, targeting, design, synthesis and optimization of heat exchanger networks (HEN); Interfacing HEN synthesis with heat exchanger design, Retrofitting, energy integration of distillation and evaporation processes, mathematical programming approach, Artificial intelligence based approaches.

CHE G621 Fluid Dynamics**2 3 5**

Mechanics of turbulent flow; semi-empirical expressions; statistical concepts; stability theory; flow of non-Newtonian fluids; stationary and moving shock waves; Prandtl-Mayer expressions; two and three dimensional subsonic and supersonic flow; methods of characteristics; small perturbation theory and similarity rules.

CHE G622 Advanced Chemical Engineering Thermodynamics**3 2 5**

Review of fundamental principles; statistical foundations; thermodynamic properties of pure substances and mixtures, their estimation and correlation; stability and equilibrium criteria for homogeneous and heterogeneous systems; thermodynamics of irreversible processes.

CHE G641 Reaction Engineering**3 2 5**

Design of multi-phase reactors; analyses of gas-liquid and gas-liquid-solid reactions; intrinsic kinetics of catalytic reactions; residence time distribution models for micro-and macro-mixing; mathematical models for gas-liquid-solid reactors; laboratory reactors; dynamics and design of various multi-phase reactors such as trickle bed reactors, bubble column reactors, segmented-bed reactors, slurry reactors, spouted bed reactors, pulsating reactors, fluidized bed reactors, etc.; optimization of chemical reactors.

Chemistry**CHEM D101 Principles of Chemistry****3 0 3**

States of matter; Elements, compounds, mixtures; Physical and chemical changes; Stoichiometry; Mole concept; Calculations of yield; Atomic and molecular masses; Molecular and empirical formula; oxidation and reduction reactions; Bohr's model of the

atom; Electronic quantum numbers; s, p, d, f orbitals; Electron spin; Electronic configurations; Periodic table; Periodic trends in atomic and ionic radii, ionization energies; Electron Affinity; Chemical Bonding: Lewis octet rule; Ionic and covalent bonding; Electronegativity; Molecular shapes; VSEPR model; Hybrid orbitals; Multiple bonds; Representative main group chemistry; Ideal Gas law; Partial pressures; Kinetic molecular theory of gases; Real gases; Reaction rates; Order of reactions; half-life; Temperature and rate; Catalysis; Work, heat, internal energy, enthalpy, first law; State functions; Hess's law; Enthalpy of formation; Entropy; Second law; Free energy and equilibrium; Equilibrium Constants (K_c and K_p); Le Chatelier's principle; Solubility and saturation; Concentrations – mole fractions, molality, molarity; Aqueous solutions: Acids, bases, salts; Brønsted and Lewis definitions, K_a and K_b ; pH; Strong and weak acids and bases; Buffers; Electrochemistry: Nernst Equation; Electrochemical Cells, batteries; Organic Compounds' IUPAC nomenclature; Inductive, electro-meric, resonance and hyper conjugation effects; Free radicals, carbocations, carbanions, electrophiles and nucleophiles, types of organic reactions.

CHEM F110 Chemistry Laboratory**0 2 1**

This laboratory course consists of experiments based on fundamental principles and techniques of chemistry emphasizing on physical-chemical measurements, quantitative & qualitative analysis and preparations.

CHEM F111 General Chemistry**3 0 3**

Principles of thermodynamics, phase and chemical equilibrium, electrochemistry, kinetics; Atomic structure, chemical bonding, solid state and structural chemistry, molecular spectroscopy; organic compounds, functional groups, structure and isomerism, stereochemistry, reactions and mechanisms, aromaticity, coordination chemistry, chemistry of representative elements.

CHEM F211 Physical Chemistry I**3 0 3**

Kinetic - molecular theory of gases; perfect gas; pressure and temperature; Maxwell distribution; collisions, effusion, mean free path; Boltzmann distribution law and heat capacities; first law of thermodynamics; p-V work, internal energy, enthalpy; Joule-Thomson experiment; second law; heat engines, cycles; entropy; thermodynamic temperature scale; material equilibrium; Gibbs energy; chemical potential; phase equilibrium; reaction equilibrium; standard states, enthalpies; Temperature dependence of reaction heats; third law; estimation of thermodynamic properties; perfect gas reaction equilibrium; temperature dependence; one component phase equilibrium, Clapeyron equation; real gases, critical state, corresponding states; solutions, partial molar quantities, ideal and non-ideal solutions, activity coefficients, Debye-Huckel theory; standard state properties of solution components; Reaction equilibrium in non-ideal solutions, weak acids-buffers, coupled reactions; multi component phase equilibrium- colligative properties, two and three component systems, solubility; electrochemical systems- thermodynamics of electrochemical systems and galvanic cells, standard electrode potentials, concentration cells, liquid junction, ion selective electrodes, double layer, dipole moments and polarizations, applications in biology, concept of overvoltage.

CHEM F212 Organic Chemistry I**3 0 3**

Basic terminology and representation of organic reactions; thermodynamics and kinetics of reactions; reactive intermediates (carbocations, carbanions, free radicals, nitrenes carbenes); aromatic chemistry; properties, preparation and reactions of alkyl halides, alcohols, ethers, amines and nitro compounds; carbonyl compounds; carboxylic acid and derivatives; carbohydrates.

CHEM F213 Physical Chemistry II**3 0 3**

Origin of quantum theory - black body radiation, line spectra, photoelectric effect; wave particle duality; wave equation: normal modes, superposition; postulates of quantum mechanics, time dependence, Hermitian operators, commutator; Schrödinger equation - operators, observables, solution for particle in a box, normalization, variance, momentum; harmonic oscillator, vibrational spectroscopy; rigid rotor, angular momentum, rotational spectroscopy; Hydrogen atom - orbitals, effect of magnetic field; Variation method - variation theorem, secular determinants; Many electron

atoms and molecules; Born Oppenheimer approximation, VB Theory, H2 in VB, Coulomb, exchange, overlap integrals states of H2; antisymmetric wavefunctions – two electron systems, Slater determinants, HF method; SCF method; term symbols and spectra - configuration, state, Hund's rules, atomic spectra, spin orbit interaction; basic MO theory, homonuclear diatomics - N2, O2, SCF-LCAO-MO, molecular term symbols; HMO theory - π electron approximation, conjugated, cyclic systems.

CHEM F214 Inorganic Chemistry I 3 0 3

Structure of molecules: VSEPR model; ionic crystal structure, structure of complex solids; concepts of inorganic chemistry: electronegativity, acid-base chemistry, chemistry of aqueous and non-aqueous solvents; descriptive chemistry of some elements: periodicity, chemistry of transition metals, halogens and noble gases; inorganic chains, rings, cages and clusters.

CHEM F223 Colloid and Surface Chemistry 3 0 3

Surface phenomena; intermolecular forces relevant to colloidal systems; forces in colloidal systems; experimental and theoretical studies of the structure, dynamics and phase transitions in micelles, membranes, monolayers, bilayers, vesicles and related systems; technical applications.

CHEM F241 Inorganic Chemistry II 3 0 3

Coordination Chemistry: Bonding - Valence Bond, Crystal Field, and Molecular Orbital theories; Complexes - nomenclature, isomerism, coordination numbers, structure, electronic spectra, magnetic properties, chelate effect; Reactions - nucleophilic substitution reactions, kinetics, mechanisms; descriptive chemistry of Lanthanides and Actinides; Organometallic Chemistry: structure and reaction of metal carbonyls, nitrosyls, dinitrogen, alkyls, carbenes, carbynes, carbides, alkenes, alkynes, and metallocenes; catalysis by organometallic compounds; stereochemically non-rigid molecules.

CHEM F242 Chemical Experimentation I 0 3 3

This course is based on laboratory experiments in the field of organic chemistry. Qualitative organic analysis including preliminary examination, detection of functional groups, preparation and recrystallization of derivatives, separation and identification of the two component mixtures using chemical and physical methods; quantitative analysis such as determination of the percentage/number of hydroxyl groups in organic compounds by acetylation method, estimation of amines/ phenols using bromate-bromide solution/ acetylation method, determination of iodine and saponification values of an oil sample; single step synthesis such as benzaldehyde to cinnamic acid; multistep synthesis such as phthalic anhydride – phthalimide – anthranilic acid; extraction of organic compounds from natural sources: isolation of caffeine from tea leaves, casein from milk, lactose from milk, lycopene from tomatoes, β - carotene from carrots etc.; demonstration on the use of software such as Chem Draw, Chem-Sketch or ISI-Draw.

CHEM F243 Organic Chemistry II 3 0 3

Introduction to stereoisomers; symmetry elements; configuration; chirality in molecules devoid of chiral centers (allenes, alkylidene-cycloalkanes, spiranes, biphenyl); atropisomerism; stereochemistry of alkenes; conformation of acyclic molecules; conformations of cyclic molecules; reaction mechanisms; asymmetric synthesis; photochemistry and pericyclic reactions.

CHEM F244 Physical Chemistry III 3 0 3

Symmetry: symmetry operations, point groups, reducible and irreducible representations, character tables, SALC, degeneracy, vibrational modes IR-Raman activity identification; matrix evaluation of operators; stationary state perturbation theory; time dependent perturbation theory; virial and Hellmann-Feynmann theorems; polyatomic molecules: SCF MO treatment, basis sets, population analysis, molecular electrostatic potentials, localized MOs; VB method; configuration interaction, Moller Plesset perturbation theory; semi empirical methods-all valence electron methods: CNDO,INDO, NDDO; Density Functional Theory: Hohenberg-Kohn theorems, Kohn-Sham self consistent field approach, exchange correlation functional; molecular mechanics.

CHEM F266 Study Project 3

These courses include projects which are oriented towards readings from published literature or books about new frontiers of development or analysis of available database. These courses are normally available to students in second or higher levels. These courses must coterminate with project reports.

CHEM F311 Organic Chemistry III 3 0 3

Applications of important reagents and reactions in organic synthesis and disconnection or synthon approach will be emphasized in this course. Basic principles of disconnection, order of events, chemoselectivity, regioselectivity etc. Common organic reagents, Organometallic reagents, Transition metal catalyzed reactions, introduction to retrosynthetic analysis using one group C-X and C-C disconnections, two group C-X and C-C disconnections, ring synthesis (saturated heterocycles), synthesis of heterocyclic compounds and complex molecules.

CHEM F312 Physical Chemistry IV 3 0 3

Weak forces; surface chemistry: interphase region, thermodynamics, surface films on liquids, adsorption of gases on solids, colloids, micelles, and reverse micellar structures; transport processes: kinetics, thermal conductivity, viscosity, diffusion, sedimentation; electrical conductivity in metals and in solutions; reaction kinetics, measurement of rates; integrated rate laws; rate laws and equilibrium constants for elementary reactions; reaction mechanisms; temperature dependence of rate constants; rate constants and equilibrium constants; rate law in non ideal systems; uni, bi and tri molecular reactions, chain reactions, free-radical polymerizations; fast reactions; reactions in solutions; heterogeneous and enzyme catalysis; introduction to statistical thermodynamics; theories of reaction rates; molecular reaction dynamics.

CHEM F313 Instrumental Methods of Analysis 3 1 4

Principles and practice of modern instrumental methods of chemical analysis. Emphasis on spectroscopic techniques such as UV-Visible, infrared, NMR (^1H , ^{13}C and other elements, NOE, correlation spectroscopies), ESR, atomic absorption and emission, photoelectron, Mössbauer, and fluorescence. Other topics will include mass spectrometry, separation techniques, light scattering, electroanalytical methods, thermal analysis, and diffraction methods.

CHEM F320 Introductory Computational Chemistry La- 0 4 2 laboratory

In this course the major focus is on practical computation of electronic structure of atoms and molecules using open source and proprietary software; specific computational experiments will be in the areas of potential energy surfaces, geometry optimization, molecular geometry from symmetry and trigonometric relations without visualization software, molecular orbitals and bonding patterns, Hartree-Fock calculations, correlation energy and size-consistency, DFT based calculations, computing excited states using CIS, EOM-CCSD jobs for computing energies of excited, ionized and electron-attached states; methods to estimate activation energy, solvent effects etc.; molecular dynamics simulation, molecular mechanics will also be explored; the actual experiments may vary and can have more specific learning outcomes so as to enhance the course with the latest developments in electronic structure theories of chemistry.

CHEM F323 Biophysical Chemistry 3 0 3

The principles governing the molecular shapes, structures, structural transitions and dynamics in some important classes of biomolecules and biomolecular aggregates will be discussed. The topics will include: structure, conformational analysis, conformational transitions and equilibria in proteins and nucleic acids; protein folding; lipids - monolayers, bilayers and micelles; lipid-protein interactions in membranes.

CHEM F324 Numerical Methods in Chemistry 3 3 4

Selected problems in chemistry from diverse areas such as chemical kinetics and dynamics, quantum mechanics, electronic structure of molecules, spectroscopy, molecular mechanics and con-

formational analysis, thermodynamics, and structure and properties of condensed phases will be discussed. The problems chosen will illustrate the application of various mathematical and numerical methods such as those used in the solution of systems of algebraic equations, differential equations, and minimization of multidimensional functions, Fourier transform and Monte Carlo methods.

CHEM F325 Polymer Chemistry

3 0 3

Types of polymers; structures of polymers; molecular weight and molecular weight distributions; kinetics and mechanisms of major classes of polymerization reactions such as step growth, radical, ionic, heterogeneous, and copolymerization methods; polymer solutions- solubility, lattice model and the Flory- Huggins theory, solution viscosity; bulk properties- thermal and mechanical properties such as the melting and glass transitions, rubber elasticity, and viscous flow; polymerization reactions used in industry.

CHEM F326 Solid State Chemistry

3 0 3

X-ray diffraction; point groups, space groups and crystal structure; descriptive crystal chemistry; factors which influence crystal structure; crystal defects and non-stoichiometry; solid solutions; interpretation of the phase diagrams; phase transitions; ionic conductivity and solid electrolytes; electronic properties and band theory; magnetic properties; optical properties; analysis of single crystal XRD data; preparation of solid state materials and the chemistry of device fabrication.

CHEM F327 Electrochemistry: Fundamentals and Applications

3 0 3

Electrode Processes: Overpotential, Faradaic and non-Faradaic processes, the ideal polarized electrode, capacitance and charge of an electrode, electrical double layer; primary and secondary cells, variables in electrochemical cells, factors affecting electrode reaction, cell resistance; Mass transfer: steady-state mass transfer, semiempirical treatment of the transient response, coupled reversible and irreversible reactions, reference electrodes; Kinetics of electrode reactions: Arrhenius equation and potential energy surfaces, equilibrium conditions, Tafel Plots; rate determining electron transfer, Nernstian, quasireversible, and irreversible multistep processes; Marcus Theory; mass transfer by migration and diffusion; basic potential step methods; Ultramicroelectrodes (UME) potential sweep methods; polarography and pulse voltammetry; controlled current techniques; impedance; bulk and flow electrolysis; electrochemical instrumentation; scanning probe techniques, STM, AFM, Scanning Electrochemical Microscopy, approach curves, imaging surface topography and reactivity, potentiometric tips, applications.

CHEM F328 Supramolecular Chemistry

3 0 3

Non-covalent interactions and their role in "supermolecules" and organized polymolecular systems; concepts of molecular recognition, information and complementarity; molecular receptors: design principles, binding and recognition of neutral molecules and anionic substrates, coreceptor molecules and multiple recognition, linear recognition of molecular lengths by ditopic coreceptors, heterotopic coreceptors, amphiphilic receptors, large molecular cages; supramolecular dynamics; supramolecular catalysis: reactive macrocyclic cation and anion receptor molecules, cyclophane type receptor, metallocatalysis, catalysis of synthetic reactions, biomolecular and abiotic catalysis, heterogeneous catalysis; transport processes and carrier design: cation and anion carriers, electron, proton and light coupled transport processes, transfer via transmembrane channels; supramolecular assemblies: heterogeneous molecular recognition, supramolecular solids, molecular recognition at surfaces, molecular and supramolecular morphogenesis; supramolecular photochemistry: photonic devices, light conversion and energy transfer devices, photosensitive molecular receptors, photoinduced electron transfer and reactions, non-linear optical properties; supramolecular electrochemistry: electronic devices, molecular wires, polarized molecular wires, switchable molecular wires, molecular magnetic devices; ionic devices, tubular mesophases, ion-responsive monolayers, molecular protonics, ion and molecular sensors, switching devices and signals, photoswitching and electroswitching devices, switching of ionic and molecular processes, mechanical

switching processes; self-assembly: inorganic architectures, organic structures by hydrogen bonding; helical metal complexes, supramolecular arrays of metal ions – racks, ladders and grids, molecular recognition directed self-assembly of organized phases; supramolecular polymers; ordered solid-state structures; supramolecular synthesis, assistance, replication; supramolecular chirality; supramolecular materials.

CHEM F329 Analytical Chemistry

3 1 4

Data handling; sample preparation; unit operations; volumetric and gravimetric analysis; chromatography; solvent and solid phase extraction; absorption and emission techniques; potentiometry, voltammetry; trace metal separation and estimation in biological and environmental samples with emphasis on green chemistry, sensors; laboratory training in some of these techniques.

CHEM F330 Photophysical Chemistry

3 1 4

Absorption of the electromagnetic radiation; photophysical processes such as fluorescence, phosphorescence, non-radiative transitions, and delayed luminescence, excimer and exciplex formation; triplet state: radiative and non-radiative transitions; energy transfer, fluorescence resonance energy transfer (FRET), quenching of fluorescence; fluorescence decay; protein and DNA fluorescence; time-resolved emission spectra (TRES); time-dependent anisotropy decays; application of photophysics for the characterization of biological and bio-mimicking systems. In addition to the theory, through simple experiments, laboratory training will be imparted.

CHEM F333 Chemistry of Materials

3 0 3

Solid state structure : unit cells, metallic crystal structures, polymorphism and allotropy, crystallographic direction and planes, closed packed crystal structures, polycrystalline materials, anisotropy; meso and micro porous materials: zeolites, composites, synthesis, characterization (XRD, SEM, TEM, AFM, FTIR, NMR, TGA, and DTA) and applications; ceramics and glass materials: crystalline and non-crystalline nature, glass-ceramics, processing; polymers: synthesis, structure, properties, inorganic polymers; mechanical properties: stress and strain, elastic and tensile properties, hardness, phase transformations, microstructure, alteration of mechanical properties; magnetic properties: atomic magnetism in solids, the exchange interaction, classification of magnetic materials, diamagnetism, pauli paramagnetism, ferromagnetism, antiferromagnetism, ferrimagnetism, superparamagnetism, ferromagnetic domains, hysteresis loop, hard and soft ferrites, applications; electrical properties: conductivity, band theory, types of semiconductors, time dependence of conductivity, mobility of charge carriers, metal-metal junction, metal-semiconductor junction, n-type and p-type semiconductors; optical properties: refraction, reflection, absorption, transmission, luminescence, photoconductivity, opacity and translucency in insulators, optical fibers; thermal properties: heat capacity, thermal expansion, conductivity, thermal stresses; corrosion: electrochemistry of corrosion of metals, different forms, environmental effects, prevention.

CHEM F334 Magnetic Resonance

3 0 3

Classical treatment of motion of isolated spins; quantum mechanical description of spin in static and alternating magnetic fields; Bloch equations; spin echoes; transient and steady state responses; absorption and dispersion; magnetic dipolar broadening; formal theory of chemical shifts; Knight shift; second order spin effects; spin-lattice relaxation; spin temperature; density matrix; Bloch-Wangsness-Redfield theory; adiabatic and sudden changes; saturation; spin locking; double resonance; Overhauser effect; ENDOR; pulsed magnetic resonance: Carr-Purcell sequence, phase alternation, spin-flip narrowing, real pulses; electric quadrupole effects; spin-spin coupling; 2D correlation spectroscopies: COSY, DQF, INADEQUATE experiments; CIDNP; electron paramagnetic resonance (EPR); nuclear quadrupolar resonance; muon spin resonance; magnetic resonance imaging.

CHEM F335 Organic Chemistry and Drug Design

3 0 3

An introduction to organic chemistry principles and reactivities vital to drug design, drug development and drug action; the role of molecular size, shape, and charge, and in drug action; proteins and nucleic acids as drug targets; bioisosterism; ADME, QSAR

and drug design; applied molecular modeling and combinatorial synthesis; Synthesis of some selected chemotherapeutic agents (e.g antifungal, antibacterial, antimalarial, anticancer etc.)

CHEM F336 Nanochemistry 3 1 4

Nano and nature, importance of nanoscience, chemistry behind nano; instruments for characterizing nanomaterials; diversity in nanosystems: chemical aspects of metallic, magnetic and semiconducting nanomaterials, carbon nanotubes and fullerenes, self-assembled monolayers, monolayer protected metal nanomaterials, core-shell nanomaterials; applications of nano materials in nanobiology, nanosensors and nanomedicine; hands on experience in laboratory.

CHEM F337 Green Chemistry and Catalysis 3 0 3

Definition and overview of the twelve principles of Green Chemistry, alternative starting materials; alternative synthesis and reagents; E factor and the concept of atom economy; the role of catalysis, alternate energy sources (microwave & ultrasound), catalysis by solid acids and bases, bio-catalysis, catalytic reduction, catalytic oxidation, catalytic C-C bond formation, cascade catalysis, enantioselective catalysis, alternative reaction media, renewable raw materials, industrial applications of catalysis.

CHEM F341 Chemical Experimentation II 0 4 4

This course is based on laboratory experiments in the fields of inorganic, physical and analytical chemistry. Quantitative separation and determination of pairs of metal ions using gravimetric and volumetric methods; Ion exchange chromatography; Separation & estimation of metal ions using ion exchangers and solvent extraction techniques; Determination of K_{eq} of $M - L$ systems by colorimetry; Preparation, purification and structural studies (magnetic, electronic and IR) of inorganic complex compounds; Physical property measurements such as conductance, pH, viscosity, surface tension, refractive index, specific rotation etc. Experiments to illustrate the principles of thermodynamics, kinetics, chemical equilibrium, phase equilibrium, electrochemistry, adsorption, etc.

CHEM F342 Organic Chemistry IV 3 0 3

The fundamental structural characteristics, synthesis and reaction of various heterocyclic compounds, natural products and biomolecules will be emphasized in this course. Structure, nomenclature and common reactions of heterocyclic compounds; synthesis, properties and reactions of three-, four-, five-, and six membered ring systems; condensed five and six membered ring systems, introduction to natural products; terpenoids, steroids, lipids, alkaloids, amino acids, peptides, proteins and vitamins.

CHEM F343 Inorganic Chemistry III 3 0 3

Inorganic elements in biological systems: role of alkali and alkaline earth metal ions, iron, copper and molybdenum; metalloenzymes. Metals in medicine: metal deficiency and disease; toxicity of mercury, cadmium, lead, beryllium, selenium and arsenic; biological defence mechanisms and chelation therapy. Molecular magnetic materials: trinuclear and high nuclearity compounds; magnetic chain compounds; magnetic long-range ordering in molecular compounds; design of molecular magnets. Other emerging topics in inorganic chemistry.

CHEM F366 Lab Project 3

CHEM F367 Lab Project 3

These courses include projects involving laboratory investigation or laboratory development in the students discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

CHEM F376 Design Project 3

CHEM F377 Design Project 3

These courses are intended to impart training in design of product/ process or other artifact to the students in the discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

CHEM F412 Photochemistry and Laser Spectroscopy 3 0 3

Photochemical events : absorption, fluorescence and phosphorescence; Jablonski diagrams; physical properties of molecules after photoexcitation; photochemical tools and techniques: spectrophotometers, fluorescence decay time measurement and analysis, flash photolysis; fundamental properties of laser light; principles of laser operation ; description of some specific laser systems : Helium-Neon, Argon ion, CO₂, Nd-YAG and ultrafast Titanium : Sapphire lasers.

CHEM F413 Electron Correlation in Atoms and Molecules 3 1 4

Matrix algebra, Matrix representation of operators; mean-field approach: the Hartree-Fock method- formulation, coulomb and exchange integrals, Fock-operator, second quantization, Slater rules, self-consistency, correlation energy; Brillouin's theorem, Koopmans' theorem; basis-sets, restricted Hartree-Fock, Roothan-Hall equations; unrestricted Hartree-Fock method, spin-contamination; restricted open-shell Hartree-Fock method; Recovery of correlation energy time independent perturbation approach: Brillouin-Wigner and Rayleigh-Schrodinger perturbation theories; Møller Plesset and Epstein-Nesbeth partitioning of molecular Hamiltonian, many-body perturbation theory; Feynman diagrams, connected and disconnected terms, size-consistency; Recovery of correlation energy: configuration interaction and other non-perturbative approaches, variational and projection approaches for obtaining CI ansatz, truncated CI and size-consistency problem, Davidson correction, pair-coupled-pair theory, coupled-electron-pair method and coupled-cluster approach; Density functional theory, N-representability, V-representability, Kohn-Sham approach, natural orbitals, exchange-correlation functionals, Levy functional.

CHEM F414 Bio and Chemical Sensors 3 0 3

Biological and chemical recognition: reaction kinetics, signals and noise, sensitivity, specificity, selectivity; IUPAC definition of biosensors, their classification based on receptors and transducers; analytical characteristics of various types of bio and chemical sensors, performance criteria of biosensors; electrochemical, optical, thermal, piezoelectric transducer selections for immunosensors and enzyme sensors; surface functionalization of transducers, novel self assembly techniques, coupling of biomolecules on different surfaces and their characterization; thermal biosensors, enzyme thermistor; miniaturization of sensors and flow injection techniques; applications in analysis such as urea, penicillin, pesticides, cholesterol; optical biosensor mechanisms: fluorescence and chemiluminescence techniques; electrochemical biosensors: impedimetric and amperometric biosensors; electrochemical quartz crystal micro balance, applications in chemical and biological analysis; flow injection systems vs. static measurements, protein-protein interaction and quantification; principle of inhibition based biosensor for enzyme and immunoassay, pretreatment techniques in bio-analysis.

CHEM F415 Frontiers in Organic Synthesis 3 0 3

Traditional and classic organic synthesis; modern synthetic strategies; systematic approach in terms of progress in reaction methodologies in synthesizing complex natural molecules; metal-catalyzed C-C and C-X couplings; direct functionalization via C-H and C-C activation; development of organocatalysis: metal-free catalysis; direct functionalization of olefins including hydroamination, hydrogenation, hydrosilylation, hydroformylation and other C-C bond forming reactions; the potential of radical chemistry for C-C and C-X bond formation; metal-catalyzed carbocyclization: from Ru and Rh-mediated cycloadditions to Pt and Au chemistry; one-pot multi-steps reactions: avoiding time and resource-consuming isolation procedures; tracing the development from the first total synthesis to the state of the art for some complex molecules.

CHEM F416 Applied Crystallography 3 0 3

Symmetry operations; space groups; X-ray diffraction; crystal nucleation and growth; single crystal; structure determination of a single crystal; crystal engineering; co-crystal and engineering; crystallographic databases.

CHEM F422 Statistical Thermodynamics**3 0 3**

Review of classical thermodynamics, principles of statistical thermodynamics, ensemble averages; Boltzmann distribution; partition functions and thermodynamic quantities; ideal gases and crystals; thermodynamic properties from spectroscopic and structural data; dense gases and the second virial coefficient; statistical mechanics of solutions; Bose-Einstein and Fermi-Dirac statistics.

CHEM F423 Astrochemistry**3 0 3**

The molecular universe; Starlight, galaxies, and clusters; Atomic and molecular astronomy, review of quantum chemistry and molecular spectroscopy; Stellar chemistry; Interstellar medium; Meteorite and comet chemistry; Cosmic-ray astrochemistry; Planetary chemistry of Venus, Mars, Titan, and other interesting planets and their satellites; Prebiotic chemistry; Primitive life forms.

CHEM F430 Atmospheric Chemistry**3 0 3**

This course aims to describe the chemical and physical processes of atmosphere by different models. The specific topics will include, the measures of atmospheric compositions, atmospheric pressure, models to explain variation in concentration of chemical species in atmosphere, atmospheric transport, continuity equation to provide quantitative measures about the variation of concentration, geochemical cycles, the green-house effect, aerosols, atmospheric chemical kinetics, stratospheric ozone, oxidation in troposphere, ozone air pollution, and acid rain.

CHEM F431 Sustainable Chemistry using Renewables**3 0 3**

Importance of the utilization of renewable resources as alternative feedstock for the chemicals and fuels industry; alternatives to current petro-based technology and processes such as biomass utilization; chemicals from renewables, bio-refinery concept, strategies for biomass utilization, Platform molecules, Degraded molecules, Biomass conversions by new catalytic/ synthetic routes, catalytic cascade reactions, one-pot multi-product synthesis; chemistry in lignocellulose conversions; bio-based oleochemicals; fine chemicals from renewables; thermo-chemical conversion to fuels and other chemicals; analyticals in thermal biomass conversions, kinetics based on tunable diode laser measurements, CFD modeling; bio-ethanol : production, upgradation and valorization; glycerol as feedstock; fatty acid epoxidation; hydrogen and carbon-di-oxide, hydrogen as a feedstock, electro-catalysis, solar-photo catalysis, fuel cells, Carbon-di-oxide capture and valorization.

CHEM F491 Special Project**3**

This is an unstructured open-ended course where under the overall supervision of an instructor-in-charge, batches of students will be attached to different instructors. Each batch will work on a specific time-bound project which is of basic or peripheral concern of his discipline. Each student must submit a project report as a culmination of his endeavour and investigation. The instructor-in-charge will determine the choice of the project and also whether or not the project report is to be submitted jointly by a group or individually by a student. The course will aim to evaluate student's actual ability to use the fundamentals of knowledge and to meet new unknown situations as demonstrated by the students' interaction with the instructors and instructor-in-charge and aggregated in the project report. The instructor-in-charge may assign specific hours for formal brain-storming sessions.

CHEM G511 Nuclear and Radio Chemistry**5**

Course description is to be developed.

CHEM G513 Advanced Nuclear and Radio-chemistry**5**

Nuclear stability, binding energy, properties of nucleons; Nuclear models (Shell Model, Liquid drop model), Radioactive decay characteristics, decay kinetics, α , β and γ decay, nuclear reactions, types, radiative capture, reaction cross section, theory of fission; Nuclear reactors – classification, Reactor power, Breeder reactors, Nuclear reactors in India, Reprocessing of spent fuel, Nuclear waste management (HLW, LLW and ILW); Detection and measurement of activity, GM counters, Gamma counters, Liquid Scintillation counting; Application of radioactivity, Szilard Chalmers reaction, Isotope dilution analysis, Neutron activation

analysis, Diagnostic and therapeutic applications of radionuclides, interaction of radiation with matter.

CHEM G521 Environmental Chemistry**5**

Energy-flows and supplies, fossil fuels, nuclear energy, nuclear waste disposal, renewable energy, industrial ecology, green chemistry, ozone chemistry, effect of SO_x , NO_x as pollutants, reformulated gasoline, water pollution and treatment, organochlorine and organophosphate pesticides, eco-system effects, Toxic chemicals – Effect of dioxins, polychlorinated biphenyls (PCBs) and species of metals such as lead, mercury, cadmium etc.

CHEM G531 Recent Advances in Chemistry**5**

The course is aimed at providing an overview of recent developments in selected areas of chemistry. Topics to be covered may be drawn from: modern theories of structure, bonding and reactivity, spectroscopy, chemical dynamics, phase transitions, surface phenomena, solid state materials, and synthetic and mechanistic organic and inorganic chemistry, or such other topics as may emerge in the development of the subject.

CHEM G541 Chemical Applications of Group Theory**5**

Groups, subgroups and classes : definitions and theorems; molecular symmetry and symmetry groups; representation of groups; character tables; wave functions as bases for irreducible representations; direct product; symmetry adapted linear combinations; symmetry in molecular orbital theory; hybrid orbitals; molecular orbitals of metal sandwich compounds; ligand field theory; molecular vibrations; space groups.

CHEM G551 Advanced Organic Chemistry**5**

Recent advances in aromatic electrophilic and nucleophilic substitution reactions and nucleophilic addition reactions; oxidation and reduction; enolates in organic synthesis; retro synthetic analysis; multiple step synthesis; protecting groups.

CHEM G552 Advanced Inorganic Chemistry**5**

Advanced coordination chemistry, reactions, kinetics and mechanism; advanced organometallic chemistry, bonding models in inorganic chemistry, inorganic chains, rings, cages and clusters; group theory and its applications to crystal field theory, molecular orbital theory and spectroscopy (electronic and vibrational); inorganic chemistry in biological systems.

CHEM G553 Advanced Physical Chemistry**5**

Equilibrium: The laws of Thermodynamics, applications to phase equilibrium, reaction equilibrium, and electrochemistry; Structure: Principles and techniques of quantum mechanics, applications to atomic and molecular structure and spectroscopy, statistical thermodynamics, molecular interactions, macromolecules, solid state; Dynamics: Molecular motion in gases and liquids, reaction rate laws, mechanisms and rate theories of complex reactions, molecular reaction dynamics, surface processes, electron transfer dynamics.

CHEM G554 Physical Methods in Chemistry**5**

Advanced spectroscopic and non-spectroscopic techniques used in chemistry; Topics will include electronic absorption spectroscopy of organic and inorganic compounds, ORD, CD; vibrational rotational spectroscopy symmetry aspects; Dynamic and Fourier transform NMR, NOE, Multipulse methods, Two-Dimensional NMR; EPR; NQR; Mossbauer spectroscopy; Magnetism; Ionization Methods: Mass spectrometry, Ion Cyclotron Resonance; Photoelectron Spectroscopy; Microscopic techniques: TEM, STM, AFM; EXAFS, XANES; X-ray Crystallography.

CHEM G555 Chemistry of Life Processes**4**

Synthesis and structures of biopolymers such as proteins and nucleic acids; nucleic acid replication, transcription and translation; lipids and biomembranes; transport across membranes; neurotransmission; enzyme and enzyme inhibitors; citric acid cycle, pentose phosphate pathway and nucleic acid metabolisms; photosynthesis; electron transport systems in respiration and oxidative phosphorylation.

CHEM G556 Catalysis 4

A comprehensive survey of the catalytic processes along with the fundamental aspects of the catalyst design and evaluation; several classes of heterogeneous industrial catalysts; their preparation, characterization and applications, recent developments in catalysis, application of nanomaterials in catalysis.

CHEM G557 Solid Phase Synthesis and Combinatorial 4 Chemistry

A comprehensive understanding of solid phase synthesis and combinatorial chemistry, basic principles of solid phase organic synthesis; solid phase organic synthesis strategies; introduction to combinatorial chemistry; analytical techniques in combinatorial chemistry; applications of the combinatorial approach in chemistry, drug development and biotechnology.

CHEM G558 Electronic Structure Theory 5

Advanced methods in theoretical and computational chemistry based on Quantum Mechanics: Review of mathematical background, N-Dimension complex vector spaces, linear variational problem, many electron wave functions and operators, operators and matrix elements; Ab-initio methods: Hartree-Fock (H-F), Configuration Interaction (CI), Many Body Perturbation Theory (MBPT); Density Functional Theory: Thomas-Fermi model, Hohenberg-Kohn theorems, derivation of Kohn-Sham equations; Development and use of software for such models.

CHEM G559 Bioinorganic Chemistry 4

Fundamentals of inorganic biochemistry; essential and non-essential elements in bio-systems, metalloproteins and metalloenzymes; role of metal ions in oxygen carriers, synthetic oxygen carriers, bioinorganic chips and biosensors; fixation of dinitrogen, environmental bioinorganic chemistry; transport and storage of metal ions *in vivo*, metal complexes as probes of structure and reactivity with metal substitution; fundamentals of toxicity and detoxification, chelating agents and metal chelates as medicines, nuclear medicines.

CHEM G561 Heterocyclic Chemistry 5

The fundamental structural characteristics; synthesis and reactions of various heterocycles with nitrogen, oxygen and sulphur heteroatom in the ring; heterocycles such as pyrrole, thiophene, furan, imidazole, thiazole, oxazole, indole, benzofuran, pyridine and quinoline; advanced synthesis and reaction mechanism of heterocyclic compound.

CHEM G562 Solid State Chemistry 4

Basics of solid state chemistry, comprehensive survey of different synthesis techniques, properties and their structural-property relationship of solid materials; introduction to special nanomaterials, ceramics, polymers, biopolymers and nanocomposites; thermal and mechanical properties of nanomaterials; nanocomposites in hydrophobic applications; recent advances in material science and technology.

CHEM G563 Advanced Statistical Mechanics 5

Review of ensembles, fluctuations, Boltzmann statistics, quantum statistics, ideal gases and chemical equilibrium; imperfect gases; distribution function theories and perturbation theories of classical liquids; electrolyte solutions; kinetic theory of gases; continuum mechanics; Boltzmann equation; transport processes in gases and Brownian motion; introduction to time-correlation function formalism.

Chinese**CHI N101T Beginning Chinese 3 0 3**

Basic grammar; sentence construction; vocabulary building; conversations; dialogues; listening; translation of simple passages.

Computer Science**CS F111 Computer Programming 3 1 4**

Basic Model of a Computer; Problem Solving-Basic Computing Steps and Flow Charting (Assignment, Sequencing, Conditionals, Iteration). Programming Constructs – Expressions, Statements,

Conditionals, Iterators/Loops, Functions/Procedures; Data Types – Primitive Types, Tuples, Choices (Unions or Enumerations), Lists/Arrays, Pointers and Dynamically Allocated Data. Input output and Files.

Laboratory Component: Programming Exercises involving development and testing of iterative and procedural programs using bounded and unbounded iterations, function composition, random access lists, sequential access lists, dynamically allocated lists, and file access.

CS F211 Data Structures & Algorithms 3 1 4

Introduction to Abstract Data Types, Data structures and Algorithms; Analysis of Algorithms – Time and Space Complexity, Complexity Notation, Solving Recurrence Relations.; Divide-and-Conquer as a Design Technique; Recursion – Recursive Data Types, Design of Recursive Functions / Procedures, Tail Recursion, Conversion of Recursive Functions to Iterative Form. Linear data structures – Lists, Access Restricted Lists (Stacks and Queues); Searching and Order Queries. Sorting – Sorting Algorithms (Online vs. Offline, In-memory vs. External, In-space vs. Out-of-space, Quick Sort and Randomization), Lower Bound on Complexity of Sorting Algorithms. Unordered Collections: Hash tables (Separate Chaining vs. Open Addressing, Probing, and Rehashing). Binary Trees – Tree Traversals. Partially Ordered Collections: Search Trees and Height Balanced Search Trees, Heaps and Priority Queues. Probabilistic/Randomized Data Structures (such as Bloom Filters and Splay Trees). Generalized Trees – Traversals and applications. Text Processing – Basic Algorithms and Data Structures (e.g. Tries, Huffman Coding, String search / pattern matching). External Memory Data structures (B-Trees and variants). Graphs and Graph Algorithms: Representation schemes, Problems on Directed Graphs (Reachability and Strong Connectivity, Traversals, Transitive Closure. Directed Acyclic Graphs - Topological Sorting), Problems on Weighted Graphs (Shortest Paths. Spanning Trees).

CS F212 Database Systems 3 1 4

Data modeling, database design theory, data definition and manipulation languages, relational data model, relational algebra and relational calculus, SQL, functional dependencies and normalization, storage and indexing techniques, query processing and optimization, transaction management - concurrency control and crash recovery; distributed databases.

CS F213 Object Oriented Programming 3 1 4

Object orientation concepts, theories and principles; fundamental concepts of the object model: classes, objects, methods and messages, encapsulation and inheritance, interface and implementation, reuse and extension of classes, inheritance and polymorphism; overloading and overriding; static and dynamic binding; multithreaded programming; event handling and exception handling; process of object oriented requirements specification, analysis and design; notations for object-oriented analysis and design; case studies and applications using some object oriented programming languages. Object Oriented Design Patterns: Behavioral, Structural and Creational.

CS F214 Logic in Computer Science 3 0 3

propositional logic – syntax, semantics, satisfiability & validity, predicate or first order logic – syntax, semantics, satisfiability & validity, completeness & compactness, Undecidability & incompleteness; Godel's incompleteness theorem; SAT solvers; verification by model checking, linear-time temporal logic (LTL), & computational tree logic (CTL). Program verification using Hoare logic & proofs of correctness; Modal logic & logic programming paradigm.

CS F215 Digital Design 3 1 4

Boolean Algebra & logic minimization; combinational logic circuits : arithmetic circuit design , Design using MSI components; Sequential Logic Circuits : flip flops & latches, registers and counters, Finite state machine ; HDL Implementation of Digital circuits; Digital Integrated Circuits ; Programmable logic devices; Memory organization ; Algorithmic State machine; Introduction to computer organization; The course will also have laboratory component on digital design.

CS F222 Discrete structures for Computer Science 3 0 3

Sets & operation on sets; relations & equivalence relations; number theory; weak & strong form of mathematical induction; principle of inclusion & exclusion, pigeonhole principle; recurrence relations & generating functions; digraphs & graphs, graph isomorphism & sub-graphs, spanning trees, Euler & Hamiltonian graphs, planar graphs, chromatic numbers & graph coloring; groups; Lagrange theorem finite groups; Rings & Fields.

CS F241 Microprocessors & Interfacing 3 1 4

Programmers model of processor, processor architecture; Instruction set, modular assembly programming using subroutines, macros etc.; Timing diagrams; Concept of interrupts: hardware & software interrupts, Interrupt handling techniques, Interrupt controllers; Types of Memory & memory interfacing; Programmable Peripheral devices and I/O Interfacing; DMA controller and its interfacing: Design of processor based system. This course will have laboratory component.

CS F266 Study Project 3

These courses include projects which are oriented towards readings from published literature or books about new frontiers of development or analysis of available database. These courses are normally available to students in second or higher levels. These courses must coterminate with project reports.

CS F301 Principles of Programming Languages 2 0 2

The course covers features of programming languages and introduces the main programming paradigms. It covers, in detail, the semantics of the features of programming languages –Control Abstraction, Data Types and Data Abstraction, Scope and Parameter passing and Concurrency related features. It covers various aspects of runtime environments like global and local data, code, function call stacks, dynamically allocated data, runtime features for exceptions and threads. Introduction to programming paradigms. Functional paradigm – formal elements of lambda calculus, introduction to syntax of common functional programming languages and programming exercises that explore the functional paradigm. Logic programming paradigm - formal elements of logic programming and programming tasks that explore the logic paradigm. Scripting as a paradigm. Domain specific languages. Applications of the principles of programming languages –program verification, software testing and security.

CS F303 Computer Networks 3 1 4

Introduction; Need for Computer Networks; Top-down vs. Bottom-up approaches; Network Services, and Protocols; Network Reference Models and Architectures, Architecture of the Internet, Types and Applications of contemporary and emerging Networks, Application-Layer Requirements, Concepts, Services and Protocols: Protocols for Web, Email, File transfer, Name Resolution, Address Assignment / Discovery, Remote Access Services, Voice/Video over IP, Webcasting, Video-Conferencing and Telepresence, Network Management Protocols and Overlay Networks; Transport Layer Requirements, Services, Concepts and Protocols; Network Layer Requirements, Concepts, Services and Protocols, Routing vs. Layer-3 Switching; QoS; Link Layer and Physical Layer Requirements, Concepts, Services and Protocols, Logical Link and Medium Access Control concepts, Physical medium dependent function, Modes of Signaling and Communication at the lower layer; IEEE 802 architecture, Bridging versus Layer-2 Switching; VLANs, VPNs, Performance vs. Security, Emerging Trends and Best Practices related to design of computer networks and internetworks.

CS F314 Software Development for Portable Devices 2 1 3

Introduction to mobile computing and emerging mobile application and hardware platforms; Developing and assessing mobile applications; Software lifecycle for mobile application – design and architecture, development – tools, techniques, frameworks, deployment; Human factors and emerging human computer interfaces (tangible, immersive, attentive, gesture, zero-input); Select application domains such as pervasive health care, m-Health; Mobile web browsing, gaming and social networking.

CS F315 Information and Communication Technologies and Development 3 0 3

Development models; Sustainable Development Goals and Millennium Development Goals; role of Information and Communication Technologies (ICTs) in development; case studies of successes and failures in different domains like low cost communication networks, education, information kiosks, livelihood, health, etc.; theories that have emerged over the years and their criticisms; evaluation of the role of ICTs in development

CS F316 Quantum Architecture and Programming 3 0 3

Quantum computing basics, quantum computer architectures, reversible computing, quantum gates, computing models, Ehrenfest's urn model, Kac-Ring model, designing quantum ALUs, Pen-dulum instruction set architecture (PISA), fault-tolerant architectures, the Steane code, Quantum processing elements, quantum RAM and quantum addressing, reversible programming, quantum compilers.

Pre-requisite: CS F215: Digital Design

CS F317 Reinforcement Learning 3 0 3

Introduction to RL and its applications, RL Goals and Rewards, Finite Markov Decision Processes, Temporal Difference Learning, Value function and Policy Evaluation, Tabular Methods, Function approximation, Sarsa, Q-learning, Approximate Solution Methods, Multi-agent RL, Actor-Critic methods including Advantage Actor Critic (A2C) and Asynchronous Advantage Actor Critic (A3C).

CS F320 Foundations of Data Science 3 0 3

Introduction to Data Science, Review of Probability, Random Variables and Probability Distributions, Bayesian probabilities, Conditional Gaussian distributions, Marginal Gaussian distributions, Bayes' theorem for Gaussian variables, Maximum likelihood and Bayesian Inference for the Gaussian, Mixtures of Gaussians, Probability Bounds, Nonparametric Methods - Kernel density estimators, Nearest-neighbour methods, Bayesian Curve Fitting, Introduction to constrained and unconstrained optimization, High Dimensional Data & Curse of Dimensionality, Dimensionality Reduction, PCA & SVD, Data Visualization Techniques, OLAP and Multidimensional Data Analysis, Data Pre-processing, Big Data & Big Data Analytics, Social Media data.

CS F321 System Security 3 0 3

Overview of computer security; Access control; Security policies – confidentiality policies, integrity policies and hybrid policies; Formalism, administration and deployment of access control models like Role-Based Access Control and extensions, Attribute-Based Access Control; System authentication and authorization; Secure system design principles; Information flow; Confinement problem; Assurance; System security evaluation; Database security; Software security and trusted systems – system vulnerabilities, program security and operating system security; Security management and audit.

CS F322 Knowledge Graphs-Foundations and Applications 3 0 3

Introduction to Knowledge Graphs: Representing knowledge, Examples of KGs, Resource Description Framework, Property-centric models, Wikidata model, Semantic modeling stack for sophisticated Knowledge Graphs, Domain discovery, Named Entity Recognition, Wrapper generation, Relation extraction, Social media information extraction, Instance Matching, Statistical Relational Learning, Knowledge Graph Embeddings, Reasoning, Structured querying, Question Answering as a stand-alone application, Linked data, Important Knowledge Graphs in Linked Open Data: DBPedia, GeoNames, YAGO, Wikidata, Enterprise Knowledge Graphs, Knowledge Graphs in Science like Gene Ontology, Chemical entities of biological interest: PubChem.

CS F342 Computer Architecture 3 1 4

Processor performance criteria, performance benchmarks, arithmetic circuits, CPU design - instruction set architecture, instruction execution, Single and Multicycle implementation, Pipeline de-

sign, Hazards, methods of overcoming hazards, Branch prediction, Memory subsystems including cache optimization, Instruction level Parallelism.

CS F351 Theory of Computation 3 0 3

Review of Set Theory - Cardinality, Countable and Uncountable Infinite Sets, Relations and Functions, Equivalence Relations. Introduction to Languages and Operations Applicable to Languages. Regular Expressions. Finite State Automata - Deterministic and Non-Deterministic – Equivalence, FSAs and Regular Expressions – Closure Properties of Regular Languages – Equivalence Classes of a Language and Minimal Automata. Non-Regular Languages. Context Free Grammars and Push Down Automata – Equivalence and Closure Properties – Normal forms and Concepts in Parsing – Languages that are not Context Free. Turing Machines – Unrestricted Grammars – Equivalence – Various Forms of TMs and their Equivalence. Recursive functions. Universal Turing machine – Reductions – Decidability – Undecidable Languages. Complexity Classes – P, NP and NP-Completeness.

CS F362 Programming Languages and Compiler Construction 4*

Overview of programming languages concepts and constructs, programming paradigms; Introduction to compiler process, phases and passes, bootstrapping of compilers; Formal languages, grammars and abstract machines; Lexical analysis, regular expressions and finite automata; Context-free grammar and push-down automata; Recursive-descent, LL and LR parsers; Semantic analysis, attribute grammar, type checking, intermediate representation; Run-time environments; Code optimization and code generation.

This course aims at understanding the fundamental concepts and constructs of programming language paradigms and particularly highlights several languages, which provide these features. It also focuses on the central features of high-level languages (like scope, environment, data types, control structures etc.), in addition to compiler design issues like parsers and syntax trees. The primary objective is to emphasize on implementation issues for the systems programmer rather than on language features from a programmer's point of view. It also aims at providing the student adequate background so as to enable him/her to gain good design skills needed for compiler writing.

CS F363 Compiler Construction 2 1 3

Introduction - Compilation and Execution Environments -Compilers and Interpreters – Requirements and Motivation; Front-end and Back-end of compilers/interpreters; Intermediate Representation and Intermediate Languages; Compile Time vs. Execution Time; Translators, and Assemblers; Virtual Machine -Just-in-Time Compilers. Structure of a Compiler – Phases and Passes. In-memory data - intermediate versions of code, symbol table. Lexical Analysis: error handling & tool construction, DFA, Defining tokens using regular expressions, Designing and implementing scanners / lexical analyzers. Parsers: Context Free Languages (introduction where needed)and Recognizing CFLs. Parsing techniques – LL , LR - LR (0),LR(1), LALR) . Intermediate Representation: Parse Trees and Abstract Syntax Trees; 3-address code. Semantic Analysis. Back End Phases: Machine Independent optimizations: Loop Optimization Techniques - Loop Unrolling, Induction variable based optimization, Loop-Invariant code elimination. Procedure Call Optimization, and Dead Code Elimination. Target Code Generation : Data Flow Analysis, Register Allocation, Instruction Selection & Scheduling. Memory Management : Memory allocation support, Memory- de-allocation – Garbage Collection Techniques. Advanced Topics :Issues in compiling Object Oriented Languages, Functional Languages, Concurrent Languages, Script & Query Languages.

CS F364 Design and Analysis of Algorithms 3 0 3

Basic Design Techniques – Divide-and-Conquer, Greedy, Dynamic Programming (Examples, Analysis, General Structure of Solutions, Limitations and Applicability). Specialized Design Techniques: Network Flow, Randomization (Examples, Analysis, Limitations). Complexity Classes and Hardness of Problems – P, NP, Reductions, NP-hardness and NP-Completeness, Reduction Techniques, Basic NP-complete problems. Design Techniques

for Hard Problems – Backtracking, Branch-and-Bound, and Approximation (General approaches and structure of solution, Analysis, and Limitations). Linear Programming – LP Problem and Simplex Algorithm, Approach for using LP for modeling and solving problems. Introduction to Design and Analysis of Parallel and Multi-threaded Algorithms.

CS F366 Lab Project 3

CS F367 Lab Project 3

These courses include projects involving laboratory investigation or laboratory development in the students discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

CS F372 Operating Systems 3 0 3

Introduction to operating systems; Various approaches to design of operating systems ; Overview of hardware support for Operating systems; Process/thread management: synchronization and mutual exclusion, inter process communication, CPU scheduling approaches ;Memory management: paging, segmentation ,virtual memory, page replacement algorithms ; File systems: design and implementation of file systems; Input/Output systems; device controllers and device drivers; Security and protection ; Case studies on design and implementation of operating system modules.

CS F376 Design Project 3

CS F377 Design Project 3

These courses are intended to impart training in design of product/ process or other artifact to the students in the discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

CS F401 Multimedia Computing 3 0 3

Introduction to multimedia; media & data streams; image, video & audio file formats; image & video processing, synthesis of sound signal; image coding & compression, video & audio codecs, low bit rate video telephony; audio-visual integration, lip reading, face animation; augmented reality; multimedia search services, content based image & video indexing; access to multimedia, human-machine interfaces, spoken language interface; algorithm vs. architecture based approaches, multimedia processors, performance quantification; case studies, vision 2010.

CS F402 Computational Geometry 3 0 3

Introduction to Computational Geometry, degeneracies and robustness, convex hull in 2D, line-segment intersection, doubly-connected edge list, computing the overlay of two subdivisions, art gallery theorem, guarding and triangulation, monotone polygons, partitioning arbitrary polygon into monotone polygons, triangulating a monotone polygon, range search problem, Kd- trees, range trees, fractional cascading, point location problem, trapezoidal maps, randomized incremental algorithm to compute trapezoidal map, post-office problem, Voronoi diagram and its properties, Algorithm to compute Voronoi diagram, Delaunay triangulation and relation with Voronoi diagram, Computing Delaunay triangulation, line and point duality, arrangement of lines, application of computational geometry.

CS F404 Computer Crime and Forensics 2 0 2

Introduction to Computer Forensics: collection, preservation, analysis, preparation and presentation of computer based evidence for the purposes of criminal law enforcement or civil litigation. Structure of Storage Media: Study of different file systems (FAT12, FAT16, FAT32, NTFS, EXT2/EXT3, etc). Study of digital forensic techniques: Disk forensics, Network forensics and Device forensics. Understanding Computer Crime, Data Acquisition, Forensic Analysis (Internet History files, Email files and major operating system files for different OS's). Study of Steganography: information hiding and retrieval. Live versus Dead forensics. Use of Forensic Tools for file system analysis, registry analysis, network analysis, etc. Introduction to computer crimes in India and abroad.

CS F406 Ethical Hacking 2 2 3

Techniques and tools for ethical hacking and countermeasures; exploit approaches – social engineering, scanning, foot-printing, enumeration, sniffers, buffer overflows, web-hacking including cross scripting, SQL injection, privilege escalation, root kits, search engine hijack, covert channel, binary auditing, services specific hacking like DNS, Email, Web servers, Proxy; techniques of bypassing security mechanisms and hardening systems and networks for countermeasures of security analysis, monitoring and analysis tools including network traffic and system logs.

CS F407 Artificial Intelligence 3 0 3

The object of this course is to give an introduction to the problems and techniques of A.I. along with the applications of A.I. techniques to the fields like natural language understanding, image processing, game theory and problem solving.

The course also aims at understanding its implementation using LISP and PROLOG languages.

CS F413 Internetworking Technologies 3 0 3

Introduction to internetworking concepts; the internet architecture; goals and key issues related to internetworking technologies; design aspects; HTTP and other relevant protocols; agent technology and tools relevant to the internet; techniques of data compression; voice, video, and interactive video-on-demand over the internet; multimedia operating systems and their impact; multimedia networking; mobile computing; internet security; case studies.

CS F415 Data Mining 3 0 3

Data Mining – introduction, fundamental concepts; motivation and applications; role of data warehousing in data mining; challenges and issues in data mining; Knowledge Discovery in Databases (KDD); role of data mining in KDD; algorithms for data mining; tasks like decision-tree construction, finding association rules, sequencing, classification, and clustering; applications of neural networks and machine learning for tasks of classification and clustering.

CS F422 Parallel Computing 3 0 3

Introduction to parallel computing; Models of parallel computers; Interconnection networks, basic communication operations; Introduction to parallel algorithms; Parallel programming paradigms; issues in implementing algorithms on parallel computers; Parallel programming with message passing interface; Performance analysis; Scalability analysis; Basic design techniques for parallel algorithms; Parallel algorithms for selected topics like sorting, searching and merging, matrix algebra, graphs, discrete optimization problems and computational geometry.

CS F424 Software for Embedded Systems 3 1 4

Real-time and Embedded Systems; Software issues in Embedded Systems; Software Development Process; Requirements Analysis – Use Cases, Identification and Analysis of use cases, Use Case Diagrams. Design – Architectural Design, Design Patterns, Detailed Design. Implementation – Languages, Compilers, Runtime Environments and Operating Systems for embedded software. Testing – Methodologies, Test Cases.

CS F425 Deep Learning 3 0 3

Basic neural networks, derivative-based optimisation, gradient descent and its variants, various learning algorithms: SGD, RMSProp, Adam, Shallow Networks, Stacking, multilayer perceptron, activation functions, parameter initialisation strategy, cost function, backpropagation using gradient descent, visual data, convolution operation, pooling, variants of convolution function, CNN architectures: Dense convolutional neural networks (DenseNets), AlexNet, VGG, etc., sequence models, GRU, LSTM, encoders-decoders, vanishing gradient, autoencoders, generative modelling, VAE, real world applications.

CS F426 Graph Mining 3 1 4

Managing and mining graphs which are massive and cannot held in main memory, applications of graphs are web, social networks, computational biology, communication networking etc., static graphs, dynamic graphs, indexing and querying graphs, graph

representation, random walks, page rank, triangular computation, Node classification, Graph clustering, graph similarity and alignment, Graph summarization, subgraph mining, streaming graphs, Deep learning for graphs

Pre-requisite: CS F211 : Data Structure and Algorithms

CS F427 Performance Analysis of Computer Networks 3 0 3

Network Delay Models, Queuing Models, Delay modelling using multi-dimensional markov chain, M/G/1 models for network systems, Erlan-B, BCC and BCQ models for TDM/FDM systems, analysing networking protocols and cellular system, Network traffic modeling, long range dependent properties of network traffic, Network of queues, closed queuing networks, Network Simulation, discrete event simulation, simulation work flow, experimental planning and factor reduction.

Pre-requisite: CS F303 : Computer Networks

CS F428 Special Topic in Computer Science 1 0 1

This is a one-unit course. This course allows a special topic of study for individuals or small groups of students who wish to gain particular or additional knowledge in a special topic. The topics can be chosen from certain recent / emerging areas of knowledge or alternatively it could also be used of covering certain advance concept and recent developments supplementing the existing full course.

CS F429 Natural Language Processing 3 0 3

Introduction to NLP and its applications, N-Gram Language Models, Vector representation of words, Parts Of Speech Tagging, Topic Modelling using Latent Dirichlet allocation, Statistical Machine Translation, Constituency Grammars, Logical Representations of Sentence Meaning, Information Extraction, Word Senses and WordNet, Question Answering, Dialog Systems and Chatbots.

CS F430 Approximation Algorithms 3 0 3

P vs NP, NP-optimization problems, approximation ratio; multiplicative and additive. Design techniques for approximation algorithms: greedy, local search and other combinatorial techniques, dynamic programming and approximation schemes, randomized techniques, LP based techniques; randomized rounding, primal-dual, iterative rounding, local ratio, dual-fitting, semi-definite programming based techniques. Hardness of approximation: approximation classes, non-approximability results, gap technique, approximation preserving reductions, and the PCP theorem.

Pre-requisite: CS F364: Design & Analysis of Algorithms

CS F431 Combinatorial Optimization 3 0 3

Linear programming (LP), simplex algorithm, duality in LP, dual simplex algorithm, applications of duality and primal-dual algorithm to solve graph problems. Polynomial-time algorithms for LP: ellipsoid algorithm, interior point methods; Karmakar's algorithm. Integer linear programming (ILP); total unimodularity and its applications. Algorithms for solving ILP problems.

Pre-requisite: CS F211: Data Structures & Algorithms

CS F432 Brain-inspired Deep Learning 3 0 3

Introduction to Brain-inspired Deep Learning, Deep Learning and Knowledge Representation in the Brain; Spiking Neurons and Neural Networks; Neural Information Processing; Evolving networks and Reservoir Computing; Applications of Brain-inspired Deep Learning and case studies; Neuromorphic technologies and hands-on coding with state-of-the-art neuromorphic software and hardware. Pedagogical approach will emphasise on student-led learning, creative thinking, and dissemination.

CS F433 Computational Neuroscience 3 0 3

Biophysics of action potentials, local field potentials (LFP) and electroencephalogram (EEG), and their recording and analysis techniques; modelling a neuron - starting with the Nobel-prize winning Hodgkin-Huxley model; information processing in neural populations; synaptic mechanisms and learning by association; meso- and macro-scale neural population networks and their dynamics; modelling of neurological disorders as observed in higher

level brain signals such as the LFP, EEG, functional magnetic resonance imaging (fMRI); validation of neural models with data. Alongside theory, students will be introduced to software tools (using python/Matlab/C based on student preferences) to simulate neural computations and models.

CS F434 Data science for Healthcare

3*

Basic concepts, principles, benefits and challenges of applying ML in healthcare; Introduction to overall clinical data mining workflow; Real life examples and applications; Introduction to healthcare systems - key entities and actors; Types of data available from different healthcare systems, handling of structured/unstructured data in healthcare; Challenges in clinical ML - data challenges, interpretability, explainability; Ethical and regulatory issues for ML and AI in healthcare - bias, fairness, privacy and security considerations; Application of Supervised Learning Techniques - classification, regression, ensemble methods, model performance and evaluation; Application of Unsupervised Learning Techniques - clustering, anomaly detection, dimensionality reduction; Deep Learning - CNN for computer vision for medical images, case study; Deep Learning - RNN for NLP on clinical text, case study; Deep Learning - Transformer for sequence data - biomedical signals, case study; Deployment of AI models in clinical workflows.

CS F435 Cyber Security Analytics and Forensics

3 1 4

Information and network security policies, NIST cyber security framework, the attackers and their motivations, security mechanisms, threats and attack impacts. State of the art cyber security data sets involving passwords, malwares, DoS etc. Techniques of log collection and analysis of firewall and IDS, data exploration, data visualization and data preparation in big data security. Statistics for security and risk analysis, computer and cyber forensics, cyber risk management. Malware detection, malware clustering, directed anomaly scoring for spear phishing detection. Application of NLP cyber threat intelligence, Clustering-based protocol classification via dimensionality reduction, detection of timing and side channel attack, knowledge discovery from network logs. Botnet attacks and its detection via network traffic analysis. Basics of building search engines for discovering vulnerable devices on Internet.

Pre-requisite: CS F303: Computer Networks

CS F436 Cyber Physical Systems and Security

3 1 4

Features of CPS, basics of synchronous model, reactive components, the components and properties of extended state machines. Fundamentals of safety requirements and safety specification, system invariants and verification of invariants, DFS and BFS, ROBDD for property verification, symbolic search for property verification. Introduction to asynchronous model and process, asynchronous design primitives, deadlock handling mechanisms, asynchronous coordination protocols: leader election, reliable transmission, wait-free consensus. Basics of liveness requirements, temporal logic, LTL specifications, model checking, Buchi automata, nested symbolic search, proving liveness. Continuous time models, models with disturbance, stability, linear systems, designing controllers: Open-Loop vs. Feedback Controller, Stabilizing Controller, PID Controllers, analysis techniques: numerical simulations, Barrier Certificates. Basics of Real-Time Scheduling, scheduler architecture, periodic job model, schedulability, EDF scheduling, Fixed-Priority Scheduling. Physical structure and communication protocols in real world CPS and safety requirements. Physics-Based Attack Detection in CPSs, Formal Security Analysis of Industrial Control Systems. Rule-based and axiomatic invariants for securing a real CPS. Case studies of CPS and security incidents.

CS F437 Generative Artificial Intelligence

3 0 3

Generative vs Discriminative models, Bayesian network vs neural networks; Autoregressive models; Variational autoencoders; Normalizing flow models; Generative adversarial networks; Energy-based models; Evaluation of Generative models; Applications and Variants and combinations of basic models; Discrete Latent Variable models, Generative Adversarial Imitation Learning, Learning data distribution; applications of deep generative models

to computer vision, speech, language processing, mechanical design, VLSI design, drug discovery, etc.

Pre-requisite: CS F429: Natural Language Processing OR BITS F464: Machine Learning OR CS F425: Deep Learning

CS F441 Selected Topics from Computer Science

3

This course is primarily intended to introduce the students of computer science to topics, either in recent advances or of special interest. Topics may be taken from one or more of the areas like artificial intelligence, theory of computing, networking and distributed processing, digital control, information theory, super computers, special purpose architectures and language processors.

CS F444 Real-Time Systems

3 0 3

Introduction to real-time systems, clock synchronization, task assignment and scheduling, programming language with real-time support, ADA, real-time communication protocols, real-time databases, fault tolerant techniques, reliability evaluation methods; case studies in real-time operating systems, simulation of real-time systems, embedded system programming.

CS F446 Data Storage Technologies and Networks

3 0 3

Storage Media and Technologies – Magnetic, Optical and Semiconductor media, and techniques for read/write operations, issues and limitations. Usage and Access – Positioning in the memory hierarchy, Hardware and Software Design for access, Performance issues. Large Storages – Hard Disks, Networked Attached Storage, Scalability issues, Networking issues. Storage Architecture. - Storage Partitioning, Storage System Design, Caching, Legacy Systems. Storage Area Networks – Hardware and Software Components, Storage Clusters/Grids. Storage QoS – Performance, Reliability, and Security issues.

CS F451 Combinatorial Mathematics

3 0 3

Course description is to be developed.

CS F468 Information Security Project

0 3 3

Malware and Malware Identification, Terminate-and-Stay-Resident programs, Identification of signatures/patterns of viruses, Developing Antivirus tools, Single system firewalls and rules, Rootkits and identification of rootkits, Virtual machines, Sandboxes and run-time monitors.

CS F469 Information Retrieval

3 0 3

Organization, representation, and access to information; categorization, indexing, and content analysis; data structures for unstructured data; design and maintenance of such data structures, indexing and indexes, retrieval and classification schemes; use of codes, formats, and standards; analysis, construction and evaluation of search and navigation techniques; search engines and how they relate to the above. Multimedia data and their representation and search.

CS F491 Special Project

3

This is an unstructured open-ended course where under the overall supervision of an instructor-in-charge, batches of students will be attached to different instructors. Each batch will work on a specific time-bound project which is of basic or peripheral concern of his discipline. Each student must submit a project report as a culmination of his endeavour and investigation. The instructor-in-charge will determine the choice of the project and also whether or not the project report is to be submitted jointly by a group or individually by a student. The course will aim to evaluate student's actual ability to use the fundamentals of knowledge and to meet new unknown situations as demonstrated by the students' interaction with the instructors and instructor-in-charge and aggregated in the project report. The instructor-in-charge may assign specific hours for formal brain-storming sessions.

CS G501 Mobile Computing

5*

Course description to be developed.

CS G511 Design and Analysis of Algorithms 3 2 5

Design techniques such as divide-and-conquer, recursion, backtracking, branch-and-bound, simulation; Analysis in terms of average level and worst level efficiency; Relationship to appropriate data structures; Illustrations dealing with problems in computer science, graph theory and mathematics; Computational complexity and bounds; NP-hard and NP-complete problems.

CS G512 Introduction to Authoring Systems 4

Characteristics and principles of expert systems; construction and transfer of expertise; meta-knowledge; tools and formalisms for expert systems; application through programs in prolog; state of art characteristics and principles of authoring systems; implementation techniques.

CS G513 Network Security 3 1 4

This course examines issues related to network and information security. Topics include security concepts, security attacks and risks, security architectures, security policy management, security mechanisms, cryptography algorithms, security standards, security system interoperation and case studies of the current major security systems.

CS G514 Object Oriented Analysis and Design 2 2 4

Object orientation concepts, theories and principles; fundamental concepts of the object model: classes, objects, methods and messages, encapsulation and inheritance, interface and implementation, reuse and extension of classes, inheritance and polymorphism; process of object-oriented requirements specification, analysis and design; notations for object-oriented analysis and design; case studies and applications using some object oriented programming languages.

CS G515 Queueing Systems Theory 3 2 5

Resource sharing issues and theory of queueing systems; Review of Markov chains and baby queueing theory; Method of stages. M/Er/1. Er/M/1. Bulk arrival and bulk service systems. Series-parallel stages. Fundamentals of open and closed queueing networks. Intermediate queueing theory: M/G/1; G/M/m. Collective marks. Advanced queueing theory: G/G/1; Lindley integral equation; spectral solution. Inequalities, bounds, approximations.

CS G516 Advanced Database Systems 3 1 4

Object-oriented databases, Parallel databases, Distributed databases, NoSQL databases, Deductive databases, Spatial databases, Multimedia databases, Query optimization, Information retrieval, XML.

CS G517 Network and System Security 4*

Course description is to be developed.

CS G518 Internet of Things: Design and Development 3 1 4

Logical design of IoT and enabling technologies, IoT protocol stack, IoT architecture and middleware design, introduction to Raspberry Pi and Python, QEMU simulator, application layer protocol like MQTT, CoAP, XMPP, XMPP-IoT, transport protocols like UDP, DTLS, TLS, RTP, STUN, data link protocols like 6LoWPAN, Wi-Fi, Bluetooth, Zigbee, WiMax, LR-QPAN, WPA2, L2CAP, SAFER+, IoT data and cloud computing, IoT data and machine learning, network performance and SDN and NFV, Blockchain and IoT.

Co-requisite CS F303 :Computer Networks OR EEE F414 OR ECE F414 : Telecommunication Switching Systems and Networks OR EEE F346 : Data Communication Networks

CS G519 Social Media Analytics 3 1 4

Basics of social media, its modelling & representation, node classification, community detection, user behaviour, herd behaviour, influence, recommendations in SM, controversy detection, sarcasm detection, fake post detection, behavioural analysis, SM driven problems such as mental health, spreading rumours, etc.

Equivalent: SS G519

CS G520 Advanced Data Mining 3 1 4

Topics beyond conventional record data mining. Mining complex data structures. Tree/graph mining, sequence mining, web/text data mining, stream data mining, spatiotemporal data mining, mining multi-variate time series data, high-dimensional data clustering, and mining social networking sites. Mining data from multiple relations (Multi-relational Data Mining). Privacy preserving Data Mining. Distributed computing solutions for data intensive data mining.

CS G521 Object Oriented Programming 2 2 4

Basics of object oriented programming: objects, classes, instances; inheritance; polymorphism; operator overloading; static and dynamic binding; small talk, C++, cases from other object oriented languages like Ada, Loop, Flavors, Objective-C, etc.; object oriented software engineering.

CS G523 Software for Embedded Systems 3 2 5

Real-time and embedded systems; software issues in embedded system; software development process; requirement analysis: use cases, identification and analysis of use cases, use case diagrams; design: architectural design, design patterns and detailed design; implementation: languages, compilers, runtime environments and operating systems for embedded software; testing: methodologies, test cases. The course will also consist of laboratory practices and development of software for embedded systems.

CS G524 Advanced Computer Architecture 3 0 5

Basics of Parallelism, Instruction Level Parallelism, Simultaneous Multi-Threading, Design and Optimization Techniques for Cache and DRAM; Pipelining and Super-scalar Techniques, Multiprocessor and Multi-core architecture, Shared Memory and Cache Coherence Issues; Multi-vector and SIMD computers, Performance evaluation methods, Interconnect Design Techniques.

CS G525 Advanced Computer Networks 3 2 5

Topics in advanced networking – Quality of Service in IP networks, IPv6, Wireless and Mobile Networks, Carrier Technologies (Frame Relay, FDDI, ISDN, ATM), Peer-to-Peer Networks and Overlays, Routing and QoS Issues in Optical Networks.

CS G526 Advanced Algorithms & Complexity 3 2 5

Advanced Algorithm Design Strategies such as Randomization, Approximation and Game-Theoretic Techniques. Design of Parallel and Distributed Algorithms. Design of algorithms for application domains such as Internet / Web, and Computational Biology.

CS G527 Cloud Computing 5

Review of Distributed computing - Concurrency, message passing, connectivity and failure models, replication. Computing Infrastructure - Processing Power, Storage aggregation, I/O & Communication, Clusters and Data Centers. Resource modeling and virtualization - CPU virtualization, memory and storage virtualization, virtualized networks. Services - Service models and service contracts; Programming on the cloud. Cloud Applications - Software on the Cloud and Infrastructure Services. Cloud infrastructure - Private vs. Public Clouds, Resource scaling and Resource provisioning. Quality of Service - Performance models, scalability, Performance measurement and enhancement techniques. Security issues - Data/ Storage Security, Resource Access Control, Process Isolation and Control, Service Policies and Privacy Issues.

CS G531 Testable Design & Fault Tolerant Computing 3 2 5

Fault: types, modelling and simulation; testing methodologies, coverage, economics and quality; test vector generation: design for testability, built-in self tests; fault tolerant computing; fault tolerant software.

CS G532 High Performance Heterogeneous Computing 3 2 5

Computing and memory aspects of modern processors, code and data access optimization techniques for high performance, heter-

ogeneous computing systems, parallel design methodology, performance analysis, efficient parallel programming with OpenMP, lock-free data structures, transactional memory, efficient parallel programming with MPI, hybrid parallelization with MPI and OpenMP, parallel I/O, GPU architectures, efficient GPU programming with CUDA, parallel patterns, programming for heterogeneous computing nodes, OpenCL and OpenACC, energy efficient program design for heterogeneous platforms.

CS G533 Software Engineering for Machine-Learned Systems 5*

Foundational topics; Introduction to software quality attributes of an AI/ML component (operating cost, latency, updateability, and explainability); Model quality; Architecture of AI enabled systems; Data handling techniques; Testing and checks data quality, data drift, feedback loops; Deployment and MLOps; Introduction to Ethics, fairness, Security and Privacy issues in AI-enabled software.

CS G541 Pervasive Computing 4*

Select application architectures; hardware aspects; human-machine interfacing; device technology: hardware, operating system issues; software aspects, java; device connectivity issues and protocols; security issues; device management issues and mechanisms; role of web; wap devices and architectures; voice-enabling techniques; PDAs and their operating systems; web application architectures; architectural issues and choices; smart card-based authentication mechanisms; applications; issues and mechanisms in WAP-enabling; access architectures; wearable computing architectures.

CS G543 Natural refrigerants and application 5*

History of natural refrigerants, Growth in HVACR sector and energy consumption, Impact of refrigerants on environment. Thermodynamic properties of natural refrigerants (Ammonia, Carbon dioxide, Hydrocarbons, Water, Air), Challenges and opportunities of Natural refrigerants, Thermodynamic modelling of various natural refrigeration system. Low charge ammonia system, Transcritical CO2 system, high ambient application, chiller application, deep freezing application, natural refrigerant in secondary loop, Multi stage compression, Booster system, Cascade and multi evaporator system, simultaneous heatingcooling, high temperature heat pump. Technologies for performance enhancement & safety assurance. Component selection and design: Gas cooler, Internal heat exchanger, Sub cooler, Work recovery expander, Ejector, Economizer, Pressure exchanger, Defrost system, Oil management system, Accumulator, Electronic expansion valve, Variable speed drive, Compressors. Waste heat recovery and heat integration, Techno-economics of natural fluids.

CS G551 Advanced Compilation Techniques 5

Generic Code Optimization Techniques - loop optimization, inlining, and other transformations. Impact of architectures on code generation and optimization: RISC architectures, VLIW architectures, special-purpose architectures. Architecture-specific code optimizations – register allocation, instruction scheduling. Code Optimizations under real-time / embedded constraints - cacheless / diskless memory models, bounded time responses. Garbage Collection Techniques. Virtual Machines and Just-in-Time Compilation techniques - HotSpot-like optimizations. Implementation of exception handling, concurrency, and generic jumps (like call/cc).

CS G553 Reconfigurable Computing 5

Overview of Programmable Logics. FPGA fabric architectures. Logic Elements and Switch Networks. Design and Synthesis of Combinational and Sequential Elements. Placement and Routing. Pipelining and other Design Methodologies. Fine-grained and Coarse-Grained FPGAs. Static and Dynamic Reconfiguration. Partitioning. Hardware/Software Portioning and Partial Evaluation. Systolic Architectures.

CS G554 Distributed Data Systems 3 2 5

Distributed File Systems - File System Models; Replication and Synchronization - Caching; Failure & Recovery; File System Se-

curity. Distributed Databases - Distributed Data Sources and Updates; Database Connectivity; Concurrency Control and Distribution mechanism; Distributed indexing schemes. Database security. Data on the Web - Web as a distributed data repository. Data Collection and Use Crawlers, Search Engines, and Indexing Schemes. Information Retrieval Techniques.

Data Exchange - Hierarchical Data Models, XML, and query languages. Semi-structured / Unstructured data -querying and synchronization.

Pervasive Data - Data distribution and access for non-computing devices, small computing devices, embedded computing devices and sensory devices.

CS G555 System Specifications and Modelling 3 3 4

Requirement analysis, specification formalisms, system modeling issues, system modeling languages, Hardware Specification and verification languages, EDA tools and its applications.

CS G557 Distributed Computing 5*

Distributed system architecture (layered, service oriented, pub-sub, p2p, middleware, messaging); Virtualization-traditional, containers, cluster; Communication mechanism, name and identity resolution; Coordination- clock, synchronous, asynchronous, gossip based; Consistency and replication-consistency model, consistency protocols; Fault-tolerance (resiliency, CAP theorem, Paxos, recovery, checkpointing); Security issues in distributed systems; Edge computing.

CS G559 Database Security 5*

Course description is to be developed.

CS G562 Advanced Architecture and Performance 3 2 5 Evaluation

Introduction to advanced architectures; parallel processing; pipelining and vector processing; array processing; SIMD computers and processor enhancement; performance evaluation methods, statistics and discrete math applications; modelling for evaluation of virtual memory; time sharing environments.

CS G564 Advanced Cryptography 5*

Course description is to be developed.

CS G566 Secure Software Engineering 5*

Best practices for designing secure systems, software engineering principles for designing secure systems, criteria for designing secure systems; analysis of system properties and verification of program correctness; use of formal methods and verification for security; tools for verification of security properties; techniques for software protection (such as code obfuscation, tamper-proofing and watermarking) and their limitations; analysis of software based attacks (and defenses), timing attacks and leakage of information, and type safety.

CS G568 Network Security Project 0 3 3

Network Intrusion and Intrusion Detection Techniques and Tools; Denial-of-Service attacks and Techniques/Tools for handling them; Network Firewalls and Firewall policies/mechanisms; Network-wide authentication schemes for users/clients/servers; Network-wide storage and storage security models and implementations.

CS G611 Distributed Processing Systems 2 2 4

Concepts of distributed processing, networkable architectures, inter process and processor communication algorithms, process migration and porting techniques etc.

CS G612 Fault Tolerant System Design 2 3 5

Principles of fault tolerant systems, redundancy, parallel and shared resources, spatial systems, configurations, design aspects etc.

CS G622 Local Area Networks: Design and Implementation 2 3 5

Introduction to Local Networks; carrier sense networks; shared memory and device systems; protocol and token passing techniques & algorithms; security and integrity problems; algorithms and implementation; and selected current topics.

CS G623 Advanced Operating Systems 3 2 5

Overview of advanced operating systems: motivation for their design, and various types of advanced operating systems; Distributed operating systems: architecture of distributed systems, theoretical foundation of distributed systems, deadlock detection/resolution, agreement protocols, file systems, distributed shared memory, scheduling, fault tolerance and recovery; Multiprocessor operating systems: multiprocessor system architectures, multiprocessor operating system design issues, threads, process synchronization, process scheduling and memory management; Data base operating systems: introduction, concurrency control: theoretical and algorithmic aspects; Case Study: Amoeba and Mach.

CS G631 Devices, Data Communications and Control 3 2 5

Principles of operations of I/O devices; device handlers; master-slave control & controllers; Intelligent mode of operation; device handlers; most popular data communication methods; synchronization and handshaking; design of controllers for selected devices.

CS G632 Application Driven System Design 0 4 4

General principles of application driven systems, examples from space and high speed digital imaging systems, Bandwidth considerations, design aspects etc

CS G641 Microprocessor-Based Systems Design 2 3 5

Small systems organisation; bus architectures; building blocks around a microprocessor; memory techniques; RAM disks; paged memory modules; communications and data transfers; monitors and operating systems; engineering applications of microprocessors as device controllers; concept of local and central control.

CS G642 Recent Advances in Computing 2 2 4

Introduction to transputing and transputers, minimization algorithms, design aspects. Neural networks modelling, simulation and design. Optical computing and recent advances.

CS G651 Symbolic Computing & Computer Algebra 2 2 4

Course description is to be developed.

CS G652 Digital Communications and Message Switching 3 2 5

Signals & transmission types; noise; coding & decoding; modulation techniques; filters; time and frequency multiplexing; message switching; protocols; packet switching systems; remote networks; satellite linking communications.

CS G653 Software Architectures 3 2 5

Systems engineering and software architectures; Hatley-Pirbhai architectural template; architecture flow diagrams; requirements engineering and software architecture; architectural design processes; design post-processing; real-time architectures; architectural design patterns; software architecture and maintenance management; object oriented architectures; client-server architectures; forward engineering for object oriented and client-server architectures; emerging software architectures.

CS G671 Advanced Computer Graphics 3 2 5

Overview of computer graphics and graphic devices; two dimensional & three dimensional curve representations, rotations and transformations; surfaces, generation, representation, rotation and transformations; modelling techniques; concepts in geometric design.

Design Engineering**DE G511 Advanced Methods in Applied Mathematics 5**

Suitable topics from amongst the following: linear algebra; vector analysis; numerical methods to solve different types of equations; approximate numerical solutions of ordinary and partial differential equations; integral transform; linear and nonlinear optimization techniques; mathematical programming; mathematical modelling; calculus of variations; random variates and statistical techniques; decision models and analysis.

DE G512 Finite Element Analysis 5

Element properties, Isoparametric elements, Finite element methods and analysis, Applications in design including continuum mechanics, Dynamic systems, Heat conduction and Electrical potentials, etc. will be taken up.

DE G513 Tribiology 3 2 5

Introduction, lubricants and lubrication, surface texture, bearing materials, fundamentals of viscous flow, reynolds equation and applications, thrust bearings, journal bearings, squeeze-film bearings, hydrostatic bearings, gas bearings, dry and starved bearings, selecting bearing type and size, principles and operating limits, friction, wear and lubrication.

DE G514 Fracture Mechanics 3 2 5

Introduction, energy release rate, stress intensity factor and complex cases, anelastic deformation at the crack tip, elastic plastic analysis through J-integral, crack tip opening displacement, test methods, fatigue failure, numerical analysis, mixed mode crack initiation and growth.

DE G521 Instrumentation and Applied Electronics 5

Generalized instrumentation system for measurement and control; performance characteristics of instruments; analytical techniques - time and frequency domain analysis, Laplace and Fourier transform techniques; sensors and transducers; Feedback measurement system, analog and digital signal conditioning and conversion techniques, telemetry techniques, improvement of signal-to-noise ratio, statistical instrumentation techniques; transducers interfacing; computer control instrumentation, electronic bench instruments, etc.

DE G522 Design Projects 3 2 5

Practice in engineering design through projects emphasizing creative solutions to engineering design problem. Illustrative case studies of design will be taken up. The course will be conducted through selected group/individual projects.

DE G531 Product Design 3 2 5

Introduction to creative design; user research and requirements analysis, product specifications, Computer Aided Design; standardization, variety reduction, preferred numbers and other techniques; modular design; design economics, cost analysis, cost reduction and value analysis techniques, design for production; human factors in design: anthropometric, ergonomic, psychological, physiological considerations in design decision making; legal factors, engineering ethics and society.

DE G532 Quality Assurance & Reliability 5

Quality planning and control, economics of quality control, Specifications, tolerances and process capability studies, total quality control concepts in quality circles, quality incentives. Fundamental concepts of reliability engineering, Failure analysis, Reliability versus quality control, Systems reliability evaluation, reliability allocation, maintainability, and designing for reliability. Illustrative examples of design ensuring reliability to be taken up.

DE G611 Dynamics & Vibrations 3 2 5

Steady and transient Vibration of single and multi degree freedom systems. Systems with distributed mass and elasticity. Non-linear and self-excited vibrations, structural damping, Random vibrations, vibration analysis, vibration control - reduction, isolation and vibration absorbers.

DE G621 Digital & Microprocessor Based Systems **5**

Digital system design using combinational and sequential circuits; processor architecture, assembly programming and system design using peripheral devices such as PPI, Interrupt controller, DMA controller, etc. Microcontroller architecture and typical applications; concept of bus based system design and PC based system design.

DE G631 Materials Technology & Testing **5**

Study of characteristics and technology of metals, plastics, rubbers, ceramics, polymers, composites, optical fibres and other modern engineering materials and their application with particular reference to Railways. Destructive and non-destructive testing techniques and their applications in Railways.

Electronics and Communication Engineering

ECE F211 Electrical Machines **3 1 4**

Transformer: Constructional features, equivalent circuit and phasor diagram - regulation and efficiency, parallel operation. Three phase transformer connections; Harmonic in transformers; Testing; Phase conversion; Autotransformer. D.C Machines: Construction, armature windings, armature voltage and torque equations, classification. D.C generators, performance characteristics; D.C motors - torque/speed characteristics, speed control and braking. Testing and efficiency. Induction machines: Constructional features and rotating magnetic field. Circuit model and phasor diagram.

Steady state characteristics. Testing, starting and speed control. Time harmonics and space harmonics. Wound rotor induction motors, Single phase induction motors - classification and equivalent circuit. Synchronous machines: Constructional features; synchronous generators and motors; equivalent circuit and phasor diagram; power and torque characteristics and capability curves. Parallel operation. Salient pole synchronous machine - phasor diagram and determination of synchronous reactances; starting and speed control of synchronous motors. Special machines- universal motors, Induction generators.

ECE F212 Electromagnetic Theory **3 0 3**

Review of mathematics - scalar and vector fields, calculus of scalar and vector fields in Cartesian and curvilinear coordinates, Dirac delta function; Electrostatics - electric field, divergence & curl of electric field, electric potential, work and energy in electrostatics, conductors, electric dipole; Electrostatics in Matter - polarization and field of a polarized object, electric displacement, linear dielectrics; Magnetostatics - Lorentz force law, Biot-Savart law, divergence & curl of magnetic field, magnetic vector potential, magnetic dipole; Magnetostatics in matter - magnetization and field of a magnetized object, the H-field, linear & non-linear magnetic media; Electrodynamics - electromotive force, electromagnetic induction, Maxwell's equations in free space, plane wave solutions of Maxwell's equations in free space.

ECE F214 Electronic Devices **3 0 3**

Crystal structure and growth of semiconductor, electrical conduction in solids, Elementary quantum physics (Photoelectric effect, uncertainty principle, Schrodinger wave equation and tunneling), energy bands in solids, charge carriers in semiconductors, excess carriers in semiconductors, Fabrication of p-n junctions, equilibrium conditions, forward and reverse biased junctions, metal-semiconductor junctions Bipolar junction transistors, field effect transistors (JFET, HEMT, MOSFET), Special diodes (varactor diode, solar cell, LEDs, Tunnel diode and HBT), dielectric materials and insulation (Polarization mechanisms, frequency dependence, dielectric strength and insulation breakdown).

ECE F215 Digital Design **3 1 4**

Boolean Algebra & logic minimization; combinational logic circuits : arithmetic circuit design , Design using MSI components; Sequential Logic Circuits : flip flops & latches, registers and counters, Finite state machine ; HDL Implementation of Digital circuits; Digital Integrated Circuits ; Programmable logic devices; Memory

organization ; Algorithmic State machine; Introduction to computer organization; The course will also have laboratory component on digital design.

ECE F216 Electronic Devices Simulation Laboratory **0 2 2**

Hands on simulation experience of Electronic Devices (Diodes, BJTs, MOSFET and MOS Capacitor) using Sentarus TCAD; Simulation of electrostatics of various Electronic Devices and their effects on the device performance.

Pre-requisites:

EEE F214 / INSTR F214 / ECE F214 : Electronic Devices

ECE F241 Microprocessors and interfacing **3 1 4**

Programmers model of processor, processor architecture; Instruction set, modular assembly programming using subroutines, macros etc.; Timing diagrams ; Concept of interrupts: hardware & software interrupts, Interrupt handling techniques, Interrupt controllers; Types of Memory & memory interfacing; Programmable Peripheral devices and I/O Interfacing ; DMA controller and its interfacing; Design of processor based system. This course will have laboratory component.

ECE F242 Control Systems **3 0 3**

Modeling and classification of dynamical systems, Properties and advantages of feedback systems, time-domain analysis, frequency-domain analysis, stability and performance analysis, State space analysis, controller design.

ECE F243 Signals and Systems **3 0 3**

This course is intended to provide a comprehensive coverage of Signals and Systems, a fundamental subject of Electrical Engineering. The topics covered are: Continuous-time and discrete time signals and systems, convolution, properties of linear time-invariant (LTI) systems, Fourier series, Fourier transform, Z transform, Laplace transform; System analysis, frequency response, analog filters, Sampling and reconstruction.

ECE F244 Microelectronic Circuits **3 0 3**

Basic microelectronic circuit analysis and design, biasing in discrete and integrated circuit amplifiers, an overview of modeling of microelectronic devices single and two transistor amplifier configurations with passive and active loads; current mirrors & current sources; single-ended and differential linear amplifiers , differential and multistage amplifiers; 2 stage CMOS OPAMP, frequency response of amplifiers; negative feedback in amplifiers, R-C frequency compensation.

ECE F266 Study Project **3**

These courses include projects which are oriented towards readings from published literature or books about new frontiers of development or analysis of available database. These courses are normally available to students in second or higher levels. These courses must coterminate with project reports.

ECE F311 Communication Systems **3 1 4**

Analysis and design of communication systems; analog and digital modulation and demodulation, frequency conversion, multiplexing, noise and distortion; spectral and signal-to-noise ratio analysis, probability of error in digital systems, spread spectrum. Introduction to the basic principles of the design and analysis of modern digital communication systems. Topics include source coding, channel coding, baseband and passband modulation techniques, receiver design, and channel equalization.

ECE F312 EM Fields and Microwave Engineering Laboratory **0 1 1**

Experiments in Microwaves and antennas using Microwave benches and simulation softwares.

ECE F314 Electromagnetic Fields and Microwave Engineering **3 0 3**

Electromagnetic waves; Maxwell's equations; Poynting theorem and wave equations; propagation of EM waves; transmission

lines; microstrip lines; wave guides; cavities and antennas; microwave generators, microwave amplifiers; measurement at microwave frequencies.

ECE F341 Analog Electronics

3 1 4

Introduction to operational amplifiers: The difference amplifier and the ideal operational amplifier models, concept of negative feedback and virtual short; Analysis of simple operational amplifier circuits; Effects of real operational amplifier parameters on circuit performance. Linear applications of operational amplifiers: Instrumentation and Isolation amplifiers; Current and voltage sources; Active filters. Non-linear applications of operational amplifiers: Comparators; Linearization amplifiers; Logarithmic amplifiers, multifunction modules & circuits, true rms convertors, Precision and signal conditioning circuits, Waveform Generation: sinusoidal and non-sinusoidal signal generation; Wave shape converters. Timer 555 based circuits, Phase lock loop circuits & applications, IC regulators, Output stage and large signal amplifiers, Power amplifiers, Tuned amplifiers, Analog and Digital interface circuits: A/D, D/A Converters.

ECE F343 Communication Networks

3 03

Packet switching and circuit switching; layered network architecture (OSI model), point-to-point protocols and links: physical layer, error detection and correction, ARQ retransmission strategy, framing, X.25 standard, queueing theory and delay analysis: Little's theorem, analytical treatment of M/M/1 and M/M/m queueing systems, simulation of queueing systems, delay analysis for ARQ system, multi-access protocols and techniques: Aloha systems, CSMA, IEEE-802 standards, routing and flow control. TCP/ IP protocols, ISDN, ATM, network security, design of a LAN system with commercially available functional units. Wireless LAN: adhoc network, security issues.

ECE F344 Information Theory and Coding

3 0 3

Random variables and random processes; Information sources and source coding theorem, Kraft inequality, Shannon-Fano codes, Huffman codes, Arithmetic Codes, Lempel-Ziv-Welch algorithm, universal source codes; channel capacity: channel capacity; noisy channel coding theorem for discrete memoryless channels; channel capacity with feedback; continuous and Gaussian channels; error control coding: linear block codes and their properties, hard-decision decoding, convolution codes and the Viterbi decoding algorithm, iterative decoding; turbo codes and lowdensity-parity-check codes; rate distortion theory: rate distortion function, random source codes; joint source-channel coding and the separation theorem; cryptography: basic concepts on cryptography and cryptanalysis, security issues; private-key encryption algorithms- stream ciphers, block ciphers, Shannon's theory; introduction to number theory - modular arithmetic, exponentiation and discrete logarithms in Galois field; public-key encryption algorithms- Diffie-Hellman public-key distribution scheme, RSA public-key cryptosystem; Message authentication, hashing functions, digital signatures.

ECE F366 Lab Project

3

ECE F367 Lab Project

3

These courses include projects involving laboratory investigation or laboratory development in the students discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

ECE F376 Design Project

3

ECE F377 Design Project

3

These courses are intended to impart training in design of product/ process or other artifact to the students in the discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

ECE F414 Telecommunication Switching Systems and Networks

3 0 3

Intoduction, electromechanical switching, pulse dialing and DTMF dialing, stored program control, space division switching, speech

digitization and transmission, time division switching, fundamentals of traffic engineering, telephone networks, signaling, data networks, layered architecture and protocols, LANs, packet switching networks, TCP/IP, ISDN, ATM networks.

ECE F416 Digital Communication

3 0 3

Introduction, the modeling and characterization of information sources, algorithms for source coding and encoding of analog output sources; Information transmission through AWGN channels using digital modulation methods and BER estimation; Digital communication through band limited Gaussian noise channels; channel coding and decoding; Wireless communication channels: its characterization and modulation schemes for such channels; emerging trends in the above field.

ECE F418 Modern Communication Technologies

3 0 3

Modern communication systems overview, Digital modulation techniques, Channel capacity and coding, Digital link improve techniques, Digital receiver design and performance analysis, Wireless communication systems: wireless channel models and link improvement techniques, multiple access schemes. Basic concept of mobile network, Optical Communication Systems: Transmitters, receivers and other optical Communication subsystem, Optical wireless systems.

ECE F423 Electronic Material Design and Simulations Laboratory

Reviewing the basic Theory for Crystalline Solids (Crystal group, real Space, reciprocal space), Introduction of the Concept of Density Functional Theory (Many Electron Scenario, Born-Oppenheimer Approximation, Hartree's Formulation, Hohenberg and Kohn Theorems, Energy Functional, Kohn Sham Scheme), Familiarization with Quantum Espresso (Plane Wave Basis Set, Exchange Correlation Functional, Pseudopotential, Brillouin Zone Sampling, Quantum Espresso input file format), Theoretical Calculation of Structural Properties of Materials (Unit Cells and Super Cells, Lattice Vectors, Ground-state Energy, Bond-Length and Bond Angles), Theoretical Calculation of Electronic Properties of Materials (Energy Band Profiles and Density of States, Projected Density of States), Theoretical Calculation of Optical Properties of Materials (Optical Spectrum), Introduction of Doping in Materials (Effects on Electronic and Optical Properties), Introduction of Strain in Materials (Effects on Electronic and Optical Properties) Simulation of 2D materials like Graphene and MoS2.

Pre-requisites:

EEE F214 / INSTR F214 / ECE F214 : Electronic Devices

ECE F424 Smart Grid for Sustainable Energy

3 0 3

Introduction to Smart grid, Renewable Power Generation and Energy Storage, Microgrid, Power System Economics and Electricity Markets, Demand Response, Various Sensing, Communication, and Control technologies, and Application of Data Science.

Pre-requisites:

EEE F242 / INSTR F242 / ECE F242 : Control Systems

ECE F428 Energy Storage Systems

3 0 3

Need of Energy Storage; Broad classification of Energy Storage Systems and applications; Electrochemical Energy Storage Systems; Battery Storage; Application oriented choice of Batteries; Electrical interface system design for Batteries with Renewable Energy sources; Battery Management Systems (BMS); Hydrogen Energy Storage; Its application as Fuel cell, Electrical Energy Storage; Thermal Energy Storage; Mechanical Energy Storage and their applications.

ECE F431 Mobile Telecommunication Networks

3 0 3

Fundamentals of mobile telecommunications, with an overview of first generation (analog) systems and more detailed coverage of second generation (digital) technologies; technology basics including descriptions of wireless network elements, spectrum allocation, frequency re-use, characteristics of the transmission medium; over the-air (OTA) interface characteristics; capacity, coverage, speech coding, channel coding and modulation techniques of TDMA and CDMA technologies; network characteristics; archi-

texture, signaling, element management of IS-41 and GSM networks; call processing; call setup and release, handoff, roaming, advanced services; mobile data communications; circuit and packet switched data services, third generation (wideband data) mobile communications system requirements/ architecture.

ECE F434 Digital Signal Processing 3 1 4

Introduction; design of analog filters; design of digital filters (IIR and FIR); structures for the realization of digital filters; random signals and random processes; linear estimation and prediction; Wiener filters; DSP processor architecture; DSP algorithms for different applications.

ECE F472 Satellite Communication 3 0 3

Review of microwave communications and LOS systems; the various satellite orbits like GEO, MEO, LEO; the satellite link analysis and design; the communication transponder system like INSAT, INELSAT etc; the earth segment and earth station engineering; the transmission of analog and digital signals through satellite and various modulation techniques employed; the multiple access techniques like FDMA, TDMA, CDMA, DAMA, etc; the INSAT program; salient features of INSAT – systems and services offered; satellite services offered by INTELSAT, INMARSAT and future satellites like IRIDIUM etc; future trends in satellite communications.

ECE F491 Special Project 3

This is an unstructured open-ended course where under the overall supervision of an instructor-in-charge, batches of students will be attached to different instructors. Each batch will work on a specific time-bound project which is of basic or peripheral concern of his discipline. Each student must submit a project report as a culmination of his endeavour and investigation. The instructor-in-charge will determine the choice of the project and also whether or not the project report is to be submitted jointly by a group or individually by a student. The course will aim to evaluate student's actual ability to use the fundamentals of knowledge and to meet new unknown situations as demonstrated by the students' interaction with the instructors and instructor-in-charge and aggregated in the project report. The instructor-in-charge may assign specific hours for formal brain-storming sessions.

Economics

ECON F211 Principles of Economics 3 0 3

Nature and scope of economic science, its relationship with other social sciences; quantification of economic variables, theories of consumer behaviour and of the firm: linear economic models; market structures; social accounting and basic elements of economic planning.

ECON F212 Fundamentals of Finance and Accounts 3 0 3

Introduction to basic accounting principles for measuring and communicating financial data, single and double entry, ledgers, journals, trading, profit and loss and appropriation accounts, trial balance and balance sheet; cash flow statements, risk-return trade off notions, security analysis, structure of capital market, primary and secondary market, introduction to financial system and its components, financial market reforms.

ECON F213 Mathematical & Statistical Methods 3 0 3

Methods of collection and presentation of statistical data; calculation and interpretation of various measures like standard deviation, variance, Kurtosis, correlation coefficient; Sampling Methods - Simple random sampling, with and without replacement, stratified random sampling. Statistic and sample moments, Sampling Distributions - Properties of Student's - t, Chi-square and F-distributions. Theory of Estimation - Point estimation, method of moments; maximum likelihood; interval estimation. Testing of Hypothesis - Statistical hypothesis, simple and composite hypothesis, critical region, types and size of error, test of simple hypothesis versus simple alternative. Analysis of Variance - Analysis of one-way classified data, application in the study of relationships. Theory of Index Numbers - Calculation of Laspeyre's, Paasche's, Fisher's and Chain index numbers, criteria of a good index number, cost of living index numbers, base shifting, splicing and deflating of index numbers. Introduction to Regression Analysis -

Specification of simple linear regression model, least square method of estimation, classical assumptions, general and confidence approach to hypothesis testing.

ECON F214 Economic Environment of Business 3 0 3

Business and Economics, Government and business; market and the role of the Government, market failure, Government and the market, government and the firm, Fiscal policy and the environment, Macroeconomic environment; macroeconomic environment of business, Business activity, employment and inflation, monetary policy and economic environment, balance of payment accounting, Business in the international environment; World trade and international monetary system; international investing; investment decisions in multinational markets; country risk; multinational corporate strategy; multinational treasury management; currency risk; globalization and multinational business, FDI, FII, pricing strategy and business.

ECON F215 Computational Methods for Economics 3 0 3

Introduction to Python; Basic econometrics with Python; Machine learning techniques in economics; Basic numerical methods in economics; Introduction to R & analysis with economic data; Introduction to MATLAB; MATLAB's applications in economics and finance.

ECON F241 Econometric Methods 3 0 3

Business environment and economy, industrial policy, industrial licensing, role of industry in economic development, monetary and fiscal policy, inflation, foreign trade and balance of payment, MRTP, FERA and FEMA Acts, business ethics and corporate governance, IPR, technology issues, liberalization, privatization and disinvestment, globalization, FDI, MNCs, international business environment.

ECON F242 Microeconomics 3 0 3

Consumer behavior under risk, production function and linear programming applications, derivation of cost and supply functions, commodity pricing under imperfect market structures, factor pricing, multimarket equilibrium, optimization over time, welfare optimization, game theory applications.

ECON F243 Macroeconomics 3 0 3

Systems of national accounts; input-output systems; flow of fund systems; monetary circulation and exchange; basic model of income determination; classical macroeconomic models; obstacles of full employment; Keynes model, derivation of IS-LM functions; three sector model; four sector model; inflation and Phillips curve; real business cycles and new Keynesian economics; monetary policy, fiscal stabilization policy; consumption hypothesis; absolute income hypothesis, permanent income hypothesis, life-cycle income hypothesis, relative income hypothesis, investment models; money supply and money demand.

ECON F244 Economics of Growth and Development 3 0 3

Economic growth and development; models of economic growth; harrod domar model, solow model, neoclassical models of economic growth, the Feldman model, Cambridge model of growth, models of technical progress, the problem of economic development; causes of underdevelopment, human development index, theories of economic development, classical and neoclassical theory of economic development, Rostow stages theory, balanced and unbalanced growth, the lewis theory of economic development, Big-push theory, Critical Minimum effort Hypothesis theory.

ECON F266 Study Project 3

These courses include projects which are oriented towards readings from published literature or books about new frontiers of development or analysis of available database. These courses are normally available to students in second or higher levels. These courses must coterminate with project reports.

ECON F311 International Economics 3 0 3

The international economy; early trade theories; comparative advantage model; neo-classical trade theories; gains from trade; offer curves, terms of trade; Edge-worth box, factor endowments

and the Heckscher-Ohlin model; alternative models of trade and intra-industry trade; the imitation-lag hypothesis; product cycle theory; international trade and economic growth; international trade policy; tariff, non-tariff trade barriers, economic integration, international trade and economic development, balance of payment accounting, foreign exchange markets and exchange rates, exchange rate determination, open economy macroeconomics; income and price adjustment mechanisms, adjustment policies, macroeconomic policy in open economy.

ECON F312 Money, Banking and Financial Markets 3 0 3

Overview of the financial system, interest rate and their role in valuation, fluctuation in interest rate, risk and term structure of interest rate, rational expectation and efficient market hypothesis, central banking and the conduct of monetary policy, money supply and credit creation, monetary transmission mechanisms, fundamentals of financial institutions, banking and management of financial institutions, commercial banking industry, risk management in financial institutions, credit risk, analysis of various financial and economic crisis.

ECON F313 Issues in Economic Development 3 0 3

Income and Growth; Facets of Underdevelopment; Structural Features; contemporary models of development and underdevelopment, poverty, inequality and development, population and economic development, urbanization and rural-urban migration, education and health in economic development, environment and economic development, trade and economic development, FDI and economic development, infrastructure and economic development. Sustainable development.

ECON F314 Industrial Economics 3 0 3

Economic analysis of the theory and practice of organization of firms and industries. Nature of competition among firms and their behaviour in various markets, with specific emphasis on imperfectly competitive markets. Tools for empirical and theoretical approaches to the analysis of industries. Issues related to price discrimination, vertical integration, advertising, research and development activities and entry and exit of firms. Government regulation of industries.

ECON F341 Public Finance Theory and Policy 3 0 3

Role of Government in modern economy, Theory of Public good and public choice; public goods and externalities, equity in distribution, Public Expenditure and Macro-economy: Determining optimal size of government, financing of public expenditure, debt versus tax financing, impact of public expenditure on the level and composition of output and employment, Government budget and cost benefit analysis, Taxation; Direct and Indirect taxes, efficiency and equity, tax incidence, models of taxation incidence, theory of optimal taxation, recent developments in theory of taxation, evolution of tax structures, tax evasion and avoidance, designing of modern tax system, reforms in direct and indirect taxes, value added tax, fiscal federalism, designing optimal government expenditure policy; Fiscal Policy Issues: Budget deficit and public debt, interdependence of fiscal and monetary policies, theory of inter-governmental transfers, theory and policy of subsidies, theory of fiscal federalism, issues of equity and efficiency, role of planning and finance commission, goods and services tax in India, new direct tax code, role of central and state FRBMs.

ECON F342 Applied Econometrics 3 0 3

This course provides a introduction to advanced estimation and econometric techniques of analysis, with particular emphasis on how these techniques can be used for the empirical testing of economic theories and/or policy prescriptions. Topics to be studied include specification, estimation, and inference in the context of models that include then extend beyond the standard linear multiple regression framework. Multiple regression analysis; analysis of generalized linear and nonlinear models; instrumental variables; maximum likelihood, generalized method of moments (GMM), and two step estimation methods; simultaneous equation models; time series processes; identification and estimation of time series models; techniques for assessing model fit; forecasting; time series analysis and models of expectations; univariate time series analysis, stationary vs. non-stationary series; ARIMA, GARCH, VAR, cointegration, granger causality, error correction

and limited dependent variable models; auto regressive distributed lagged variable models multivariate time series analysis; dynamic models; analysis of panel data, balanced and unbalanced panel data, mixed, fixed and random effect models.

ECON F343 Economic Analysis of Public Policy 3 0 3

This course deals with the contributions of economic analysis to public policy and governance. It focuses on evaluating the rationale for government intervention in the economy and evaluating the efficiency, incentive, and distributional effects of social and economic policies. Introduction to of economic analysis; economic tools in valuing outcomes; measuring outcomes in policies and programme; policy making; the market and the public policy, policy framework and regulation, market and government issues, distribution and policy analysis; applications in tax policies, welfare policies, government policies relating to contracting, health, education, labour and employment, energy policy, competition policy, gender, rural-urban development, food security, climate change, infrastructure policy, financial and trade policy.

ECON F344 Models in Operations Management 3 0 3

Project Management Tools and Techniques, Forecasting Techniques, Quality Management Tools, Facility layout and location models, inventory management, aggregate planning, and scheduling.

ECON F345 Behavioral Economics 3 0 3

Behavioral decision theory; perspective on psychology and economics; heuristics and biases; bounded rationality; classical expected utility model; choice under uncertainty (and certainty); probabilistic judgment; and inter-temporal choice; responses to games; analogous games.

ECON F351 Indian Economic Development 3 0 3

Indian Economic Development; Understanding the Indian Economy, Growth of GDP and Per Capita Income, Planning for the economy; plan models, Five Year Plans, Sectoral Aspects; Regional Variations, Economic Reforms, Monetary Policy, Nationalization of Banks, Financial Sector Reforms; Role of Central Banking in India. External Sector; Growth and structure of India's international trade; Balance of Payments, Import and Export Policies, India, World Bank and IMF. Agricultural Policy; Land Reform, Agricultural Growth and Productivity, Irrigation; Green Revolution and After, Price Policy; Subsidies; Impact of WTO. Industrial Policy; Industrial Controls and Licensing, Productivity and Growth, Industrial Credit Industrial Sickness-Foreign Investment, Industrial Reforms, Investment, Regional Variations, Impact of WTO, Social Sectors, Health and Education, Poverty and Inequality in India, Human Development Indicators.

ECON F352 Management of Banks and Institutions Financial 3 0 3

Overview Of Banking Industry And Regulations; Critical Analysis Of Bank's Balance Sheet, Cost Of Funds Evaluation Of Bank Performance; Management Of Profit & Loss Accounts Of A Bank; Management Of Non-Interest & Non-Fund Income and Expenses; Assessment & Management of Risks; Interest Rate Risk, Credit Risk, Market Risk, Operational Risk, Liquidity Risk Etc., Basel Accords, Correspondent Banking; Mortgage And Asset-Backed Securities; Securitization, Innovation In Banking.

ECON F353 Energy Economics and Policy 3 0 3

Global Energy and Climate Policy; population and energy, energy intensity, energy crisis and alternate sources; understanding cost-benefit analysis, life-cycle cost analysis and pricing developments, analysing and managing risks; energy and environment, energy security and governance; economics of changing role of crude oil, natural gas, coal, nuclear power and renewable power; global energy markets and the challenge of mitigating global climate change. Geopolitical dimensions of energy supply and demand, regulatory approaches to cutting greenhouse gases and building a low-carbon economy; future of energy scenario.

ECON F354 Derivatives and Risk Management 3 0 3

Overview of Financial Markets. Introduction to derivatives. Definition of future, forward, option and swap. Difference between various players of derivative market, their motives and types of position they can hold. Mechanics of future, option & swap markets. Hedging strategies. Option Pricing and understanding of various factors affecting option price. Calculations of Greeks. Introduction to interest rates, yield, term structure and forward rates. Mechanics of Bond Market. Review of concept of compounding and time value of money. Difference between floating rate and fixed income bonds. Price quotes and accrued interest. Pricing of Bonds. Computation of yield. Bond Price volatility. Duration, Modified Duration and convexity. Factors affecting Bond Yields and the Term Structure. Concept of Risk. Perspective of Risk from view point of individuals, companies & financial institutions. Commercial Banks and risks faced by them. Different types of Insurance and risk faced insurance companies. Introduction to various risks: Market Risk, Credit Risk, Operational Risk, Liquidity risk & Model Risk. Concept of Value at Risk.

ECON F355 Business Analysis and Valuation 3 0 3

Theory of finance, value maximization, stakeholder theory, and corporate objective function: value creation – ways and means, business analysis: The techniques of strategy and competitive analysis, value chain analysis for competitive advantages, business valuation – approaches and methods, the dark side of valuation: strategic investment decisions.

ECON F356 Strategic Financial Management 3 0 3

Company Value and the Manager's Mission: Introduction to Valuation, Why Value Value? The Value Manager, Cash Is King and Value-Based Management. Approach to Valuation - A Practitioner's Guide: Frameworks for Valuation. Valuation Methods: Discounted, Relative and Contingent Claim. Analyzing Historical Performance. Forecasting Performance. Estimation of Discount Rates. Estimation of Cash Flows. Estimation of Growth Rates. Valuation Models: Dividend-Discount Models, Free-Cash-Flow-To-Equity Discount Models, Free-Cash-Flow-to-firm Approach, Price / Earnings Ratio, Price/Book Value Ratio and Price/Sales Ratio. Measuring and Managing the Company Value: Company Value vs. Shareholders Wealth Maximization - TSR. Economic Value Added, Market Value Added and Cash Value Added. Wealth Creator by the Indian Corporates. Analyzing the Company Performance - Application of Balanced Scorecard (BSC). Applying Valuation: Multibusiness Valuation. Mergers, Acquisition, and Joint Ventures.

ECON F357 Management Control System 3 0 3

The nature of management control system, management control environment; understanding strategies, revenue and expense centers, profit centers, transfer pricing, measuring and controlling assets employed, The management control process; strategic planning, budget preparation, analyzing financial performance, performance measurement, management compensation, Variation in management control; controls for differentiated strategies, service organizations, multinational organizations, management control projects.

ECON F366 Lab Project 3**ECON F367 Lab Project**

These courses include projects involving laboratory investigation or laboratory development in the students discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

ECON F376 Design Project 3**ECON F377 Design Project 3**

These courses are intended to impart training in design of product/ process or other artifact to the students in the discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

ECON F411 Project Appraisal 3 0 3

Criteria for selection of a project; factor intensity; commercial profitability; national economic-profitability; limitations of market prices; estimation of shadow prices; linkup project appraisal to national objectives; McGaughey and Thorbeck approach; Little-Mirrlees method; UNIDO guidelines approach; limitations of the conventional project appraisal; towards a new framework for project appraisal.

ECON F412 Security Analysis and Portfolio Management 3 0 3

Introduction to investment and securities; profile of financial assets; new issue market or primary market, initial public offerings (IPO); secondary market; framework of risk & return; fundamental analysis- economy, industry; company analysis; stock evaluation models; multiple holding period and multiple growth rate; bond analysis and bond management strategies; technical analysis; efficient market theory; portfolio management; Markowitz model; Sharpe's Single Index model; capital asset pricing model; financial derivatives-options & futures.

ECON F413 Financial Engineering 3 0 3

Introduction; Review of Markets, Players, and Conventions; Cash Flow Engineering with Forward Contracts; Engineering Simple Interest Rate Derivatives; Swap Engineering; Report Market Strategies; Dynamic Replication Methods and Synthetics; Mechanics of Options; Options Engineering with Applications; Pricing Tools; Applications of Fundamental Theorem of Finance; Fixed Income Engineering; Tools for Volatility Engineering; Volatility Swaps and Volatility Trading; Engineering of Equity Instruments: Pricing and Replication, computational methods such as Monte Carlo Simulation.

ECON F414 Creating and Leading Entrepreneurial Organizations 3 0 3

Fundamentals of entrepreneurship; entrepreneurship development in emerging markets; entrepreneurial leadership; creativity and business ideas; identifying business opportunities; legal aspects of business; entrepreneurship and intellectual property rights; business plans; marketing plan; operation and production plan; venture team and organizational plan; insights from financial statements; issues in raising finance; venture capitalist evaluation of business plans; launching a venture; corporate strategies for growth; people skills, Public issue; revival, exit and end to a venture.

ECON F415 New Venture Creation 3 0 3

Entrepreneurship as career option, idea to opportunity – market analysis and segmentation, presenting a pitch deck, building the startup team, industry and competition analysis, lean startups, product development, protection of intellectual property, sales and marketing, business models, financing options and strategies, launching a business, growth and exit strategy, social entrepreneurship, business plan presentation skills.

ECON F416 Regional Economics 3 0 3

Concept of a region; scope and method of regional economics; criteria for location of economic activities; regional economic structure; measurement of regional economic activity; interregional theory of income and trade; regional economic growth and its impact on regional structure; public policy.

ECON F418 Quantitative Analysis of International Trade 3 0 3

Global trade and empirical facts of International trade, Nature of Globalization process and benefits and costs associated with it, Theory and empirical testing of trade theories, Alternative trade theories and their empirical tests, Gains from trade and the impact of trade on income distribution, Instruments of trade policy and welfare effects, International factor movements and the impact and spillover effects of FDI and portfolio investments, Different forms of Economic integration and their benefits and costs, Technology and growth, International Technology Transfer, Exchange rate and balance of payments, Trade policy simulation using software, WTP Negotiations

ECON F419 Advanced Microeconomics**3 0 3**

Household behaviour and consumer choice; firm's Behaviour; Partial equilibrium analysis; Imperfect competition models; Price discrimination strategies; General equilibrium analysis: with and without production; Linear Programming and input-output analysis; Asymmetric information issues in economics; Modern welfare criteria; Arrow's impossibility theorem; Elements of welfare economics.

Pre-requisites: ECON F242 Microeconomics

ECON F420 Applied Macroeconometrics**3 0 3**

Macroeconomic data; Basic Time Series Concepts; Time series aggregation and Cycles; Univariate Time Series Models; Multivariate Time Series Models - VAR models, Granger Causality, Impulse Response Function, Cointegration, and Vector Error-Correction Models; Panel Data Methods; Macro-models - Dynamic Stochastic General Equilibrium Models (DSGE), Real Business Cycle (RBC) Model, Heterogeneous Agent Models, Monetary Models.

ECON F422 Functions and Working of Stock Exchanges**3 0 3**

Overview of financial markets and instruments; stock exchanges in India; trading and settlement procedures; listing; risk management; primary markets; debt markets; indices; mutual funds; derivatives; exchange traded funds; corporate governance; SEBI and regulation of the markets; important events in the stock markets; market microstructure; empirical studies on the Indian markets.

ECON F471 Resources and Environmental Economics**3 0 3**

Introduction to Environmental Economics; Economy-Environment interaction; Environment vs. Development, Environmental Kuznet's curve, Economics of Exhaustible Resources; Solow-Harwick's Rule; Market structure and optimal extraction policy; Uncertainty and the rate of resource extraction; Resource scarcity, Economics of Renewable Resources; Economics of Biodiversity, The Theory of Externality and Public Goods; Concepts; Market Failure; Pigouvian Solution; Buchanan's Theory; Coase's theorem and its critique; Pigouvian vs. Coasian solution; Detrimental externality and non convexities in the production set; Property rights; Collective action, Techniques of Valuation; Physical linkage methods; Abatement cost methods; Behavior linkage methods; Social cost benefit analysis, Environmental impact assessment.

ECON F491 Special Projects**3**

This is an unstructured open-ended course where under the overall supervision of an instructor-in-charge, batches of students will be attached to different instructors. Each batch will work on a specific time-bound project which is of basic or peripheral concern of his discipline. Each student must submit a project report as a culmination of his endeavour and investigation. The instructor-in-charge will determine the choice of the project and also whether or not the project report is to be submitted jointly by a group or individually by a student. The course will aim to evaluate student's actual ability to use the fundamentals of knowledge and to meet new unknown situations as demonstrated by the students' interaction with the instructors and instructor-in-charge and aggregated in the project report. The instructor-in-charge may assign specific hours for formal brain-storming sessions.

ECON G511 Dynamic Modeling and Control of National Economies**5****ECON G521 Modern Cost Engineering****5**

Course description for the above courses are to be developed.

ECON G531 Theory of Macroeconomic Policy**5**

This course focuses on macroeconomic policy as the major application of the theoretical material and also considers the implications of macroeconomic events for asset price determination, management, decisions, social problems and personal employment and retirement planning.

Topics to be covered are: the foundations of aggregate supply and demand: use of AD-AS model; the business cycle; applications in the areas of asset market, management decisions, social problems, etc.

ECON G541 Economic Systems Analysis**5**

Course description is to be developed.

ECON G542 Accounting Theory and Empirical Research**4**

Introduction; Association between returns and earnings; Earnings response coefficients; Earnings announcements; Earnings and the variance of returns; Earnings and the volume of trade; Market Efficiency (Post-Earnings Announcement Drift); Earnings and Prices/Returns – Theory; Cash versus Accruals; Accounting Measurement and Value Relevance; Voluntary Disclosures; Disclosure Level and the Cost of Equity; Accounting Choice and Equity Contracts; Accounting Choice and Debt Contracts; Accounting Choice and Political Costs; Modelling Discretionary Accruals; Adoption of IFRS; Process of conducting empirical accounting research.

ECON G543 Advanced Corporate Finance**4**

Information asymmetry and agency problem; Investment at the Firm Level; Corporate Cash Holdings; Corporate Financial Policy and the Value of Cash; Corporate Cash Reserves and Acquisitions; Within Firm Capital Allocation; Corporate Diversification and Firm Value; Corporate Restructuring; Mergers & Acquisitions; Leveraged Buyouts, Spin offs and Divestitures; Corporate Governance; Introduction to Behavioral Finance; Managerial Optimism; CEO Overconfidence.

ECON G544 Empirical Asset Pricing**4**

Preliminaries: Background and Statistics of Asset Pricing; Pricing Tests and Market Efficiency; Cross-Sectional and Time-Series Asset Pricing Test; Market Efficiency, Inefficiency, and Limits to Arbitrage; Return Predictability and Performance Evaluation; Evaluating Portfolio Managers; Alphas and Betas; Value & Momentum; New Directions in Empirical Asset Pricing; Robustness of Anomalies; Other Asset Markets; The Financial Crisis and the Future of Quantitative Investing; Trading and Liquidity; Algorithmic and High-Frequency Trading.

ECON G545 Financial Economics**4**

Decision making under uncertainty; Expected utility representations; Risk aversion and insurance premium; Stochastic dominance; Mean variance portfolio analysis; Characterization of minimum variance portfolio and its properties; Case of riskless asset; Asset pricing models; Capital asset pricing model; Arbitrage pricing theory; Intertemporal consumption and equity premium puzzle; Market efficiency and its critique; Forms of efficiency and tests of efficiency; Anomalies and noise trader model.

ECON G546 Topics in Econometrics**4**

Introduction; Fundamentals of Randomization Inference: The basic problem of causal analysis; Potential outcomes causal model; Approaches to identification: Randomized trials; Selection on observable; Difference-in-Differences; Two way fixed effects with differential timing; Synthetic control methods; Matching and subclassification: Exact matching and approximate matching Instrumental variables; Homogeneous treatment effects; Two-stage least squares; Weak instruments; Heterogeneous treatment effects; Identification; Estimation; Placebo checks; Interpretation; External validity; Quantile regression for causal analysis; Quantile regression with exogenous repressors and instrument variable strategies with quantile regression; Regression discontinuity design; Sharp regression discontinuity design and fuzzy regression discontinuity design; Identification; Estimation; Falsification checks; Multiple cut-offs; Multiple running variables; External validity; Regression kink designs.

ECON G547 Topics in Macroeconomics**4**

Equilibrium output and models of employment & wages; The quantity theory of money; The classical theory of the interest rate; Fiscal and Monetary Policy implications of the Classical equilib-

rium model; Models of income determination; Components of aggregate demand; Consumption theory; Investment theory; Determination of rate of interest; The IS-LM model in a closed and open economy; Policy effect of IS-LM model in closed and open economy; The AD-AS model; Monetarist model; Models of inflation, output and unemployment; Rational Expectations and New Classical Macroeconomics; Real Business Cycle theory (Real Business Cycle and Inter-temporal substitution of labor, Technology Shock, Neutrality of money and flexibility of wages and prices, Real Business cycle view on great depression); New Keynesian Theory (Imperfect competition and price setting, Menu cost models, implicit wage contract theory, efficiency wage theory, Insider-Outsider model); The Solow growth model; Infinite-horizon and Overlapping generation model (The Ramsey-CassKoopman Model, The diamond model); Endogenous growth model; Optimal Macroeconomic Policy; Financial Frictions; House Prices; Unconventional Monetary Policy; Pandemic and Macroeconomic Policy.

ECON G548 Topics in Mathematical Economics 4

Metric Spaces; Set properties- compactness, convexity, connected; Equivalence relations of a set; Functions- concave, convex, quasiconcave, homogeneity, homotheticity; Economic applications and implications of these; Fixed point theorems and applications; Geometry of matrices; Quadratic forms; Solutions to system of equations; Partitioned matrices; Characteristic roots and vectors; Vector and matrix differentiation; Definiteness of matrices; Generalized eigenvalues and eigenvectors; Applications of linear independence; Input-Output matrices; Static Optimisation-constraint and unconstrained optimization, Equality constraints, Inequality constraints, Kuhn-Tucker theorem, Concave Programming without differentiability, Multipliers, Value functions, Comparative statics; Dynamic Optimisation- Autonomous systems-asymptotic behavior, steady states and stability, calculus of variations, Bellman's equation, Optimal control theory, Discounting, Phase diagram, Multi-period optimal investment models, Multi-period optimal consumption models.

ECON G549 Topics in Microeconomics 4

Preferences & Utility; Intertemporal Consumption Analysis; Welfare Analysis; Empirical Issues; Behavioural Developments; Modelling Household Behaviour; Uncertainty and Risk; Modelling Risk Aversion; Anomalies and Way Forward; Financial Markets; Firm's Behaviour; Pricing Theory; General Equilibrium; Welfare Theorems; Comparative Analysis of Different Market Structures; Externalities; Public Goods; Coase Theorem; Endowment Effects; Adverse Selection and Moral Hazard; Asymmetric Information Issues in Banking Sector; Asymmetric Information Issues in Policy Implementation; Auctions.

Electronics and Computer Engineering

ECOM F211 Data Structures & Algorithms 3 1 4

Introduction to Abstract Data Types, Data structures and Algorithms; Analysis of Algorithms – Time and Space Complexity, Complexity Notation, Solving Recurrence Relations.; Divide-and-Conquer as a Design Technique; Recursion – Recursive Data Types, Design of Recursive Functions / Procedures, Tail Recursion, Conversion of Recursive Functions to Iterative Form. Linear data structures – Lists, Access Restricted Lists (Stacks and Queues); Searching and Order Queries. Sorting – Sorting Algorithms (Online vs. Offline, In-memory vs. External, In-space vs. Out-of-space, Quick Sort and Randomization), Lower Bound on Complexity of Sorting Algorithms. Unordered Collections: Hash tables (Separate Chaining vs. Open Addressing, Probing, Rehashing). Binary Trees – Tree Traversals. Partially Ordered Collections: Search Trees and Height Balanced Search Trees, Heaps and Priority Queues. Probabilistic/Randomized Data Structures (such as Bloom Filters and Splay Trees). Generalized Trees – Traversals and applications. Text Processing – Basic Algorithms and Data Structures (e.g. Tries, Huffman Coding, String search / pattern matching). External Memory Data structures (B-Trees and variants). Graphs and Graph Algorithms: Representation schemes, Problems on Directed Graphs (Reachability and Strong Connectivity, Traversals, Transitive Closure. Directed Acyclic Graphs - Topological Sorting), Problems on Weighted Graphs (Shortest Paths. Spanning Trees).

Equivalent: CS F211 & IS F211: Data Structures & Algorithms

ECOM F213 Object Oriented Programming 3 1 4

Object orientation concepts, theories and principles; fundamental concepts of the object model: classes, objects, methods and messages, encapsulation and inheritance, interface and implementation, reuse and extension of classes, inheritance and polymorphism; overloading and overriding; static and dynamic binding; multithreaded programming; event handling and exception handling; process of object-oriented requirements specification, analysis and design; notations for object-oriented analysis and design; case studies and applications using some object-oriented programming languages. Object Oriented Design Patterns: Behavioural, Structural and Creational.

Equivalent: CS F213 & IS F213: Object Oriented Programming

ECOM F214 Electronic Devices 3 0 3

Crystal structure and growth of semiconductor, electrical conduction in solids, Elementary quantum physics (Photoelectric effect, uncertainty principle, Schrodinger wave equation and tunneling), energy bands in solids, charge carriers in semiconductors, excess carriers in semiconductors, Fabrication of p-n junctions, equilibrium conditions, forward and reverse biased junctions, metal-semiconductor junctions Bipolar junction transistors, field effect transistors (JFET, HEMT, MOSFET), Special diodes (varactor diode, solar cell, LEDs, Tunnel diode and HBT), dielectric materials and insulation (Polarization mechanisms, frequency dependence, dielectric strength and insulation breakdown).

Equivalent: EEE F214, INSTR F214 & ECE F214 : Electronic Devices

ECOM F215 Digital Design 3 1 4

Boolean Algebra & logic minimization; combinational logic circuits : arithmetic circuit design , Design using MSI components; Sequential Logic Circuits : flip flops & latches, registers and counters, Finite state machine ; HDL Implementation of Digital circuits; Digital Integrated Circuits ; Programmable logic devices; Memory organization ; Algorithmic State machine; Introduction to computer organization; The course will also have laboratory component on digital design.

Equivalent: CS F215, ECE F215, EEE F215 & INSTR F215: Digital Design

ECOM F222 Discrete Structures for Computer Science 3 0 3

Sets & operation on sets; relations & equivalence relations; number theory; weak & strong form of mathematical induction; principle of inclusion & exclusion, pigeonhole principle; recurrence relations & generating functions; digraphs & graphs, graph isomorphism & sub-graphs, spanning trees, Euler & Hamiltonian graphs, planar graphs, chromatic numbers & graph coloring; groups; Lagrange theorem finite groups; Rings & Fields.

Equivalent: CS F222 & IS F222: Discrete structures for Computer Science

ECOM F241 Microprocessors and Interfacing 3 1 4

Programmers model of processor, processor architecture; Instruction set, modular assembly programming using subroutines, macros etc.; Timing diagrams ; Concept of interrupts: hardware & software interrupts, Interrupt handling techniques, Interrupt controllers; Types of Memory & memory interfacing; Programmable Peripheral devices and I/O Interfacing ; DMA controller and its interfacing: Design of processor based system. This course will have laboratory component.

Equivalent: CS F241, ECE F241, EEE F241 & INSTR F241: Microprocessors and Interfacing

ECOM F242 Control Systems 3 0 3

Modeling and classification of dynamical systems, Properties and advantages of feedback systems, time-domain analysis, frequency-domain analysis, stability and performance analysis, State space analysis, controller design.

Equivalent: ECE F242, EEE F242 & INSTR F242: Control Systems

ECOM F243 Signals and Systems**3 0 3**

This course is intended to provide a comprehensive coverage of Signals and Systems, a fundamental subject of Electrical Engineering. The topics covered are: Continuous-time and discrete time signals and systems, convolution, properties of linear time-invariant (LTI) systems, Fourier series, Fourier transform, Z transform, Laplace transform; System analysis, frequency response, analog filters, Sampling and reconstruction.

Equivalent: ECE F243, EEE F243 & INSTR F243: Signals and Systems

ECOM F244 Microelectronic Circuits**3 0 3**

Basic microelectronic circuit analysis and design, biasing in discrete and integrated circuit amplifiers, an overview of modeling of microelectronic devices single and two transistor amplifier configurations with passive and active loads; current mirrors & current sources; single-ended and differential linear amplifiers, differential and multistage amplifiers; 2 stage CMOS OPAMP, frequency response of amplifiers; negative feedback in amplifiers, R-C frequency compensation.

Equivalent: ECE F244, EEE F244 & INSTR F244: Microelectronic Circuits

ECOM F266 Study Project**3**

These courses include projects which are oriented towards readings from published literature or books about new frontiers of development or analysis of available database. These courses are normally available to students in second or higher levels. These courses must coterminate with project reports.

ECOM F313 Analog & Digital VLSI Design**3 0 3**

Moore's Law, Y chart, MOS device models including Deep Sub-Micron effects; an overview of fabrication of CMOS circuits, parasitic capacitances, MOS scaling techniques, latch up, matching issues, common centroid geometries in layout. Digital circuit design styles for logic, arithmetic and sequential blocks design; device sizing using logical effort; timing issues (clock skew and jitter) and clock distribution techniques; estimation and minimization of energy consumption; Power delay trade-off, interconnect modelling; memory architectures, memory circuits design, sense amplifiers; an overview of testing of integrated circuits. Basic and cascaded NMOS/PMOS/CMOS gain stages, Differential amplifier and advanced OPAMP design, matching of devices, mismatch analysis, CMRR, PSRR and slew rate issues, offset voltage, advanced current mirrors; current and voltage references design, common mode feedback circuits, Frequency response, stability and noise issues in amplifiers; frequency compensation techniques.

Equivalent: EEE F313 & INSTR F313: Analog & Digital VLSI Design

ECOM F321 Real Time Operating Systems**3 1 4**

Introduction to Real-Time Systems, Overview of General Purpose Operating Systems, Real-Time Systems – Hardware Components, Real-Time Operating Systems, Task Scheduling for RTOS, Resource Sharing and Access Control in RTOS, Concurrent Programming in RTOS, Fault Tolerance in Real Time Operating Systems.

Pre-requisites: CS F111: Computer Programming

ECOM F342 Computer Architecture**3 1 4**

Processor performance criteria, performance benchmarks, arithmetic circuits, CPU design - instruction set architecture, instruction execution, Single and Multicycle implementation, Pipeline design, Hazards, methods of overcoming hazards, Branch prediction, Memory subsystems including cache optimization, Instruction level Parallelism.

Equivalent: CS F342: Computer Architecture

ECOM F343 Communication Networks**3 0 3**

Packet switching and circuit switching; layered network architecture (OSI model), point-to-point protocols and links: physical layer, error detection and correction, ARQ retransmission strategy,

framing, X.25 standard, queueing theory and delay analysis: Little's theorem, analytical treatment of M/M/1 and M/M/m queueing systems, simulation of queueing systems, delay analysis for ARQ system, multi-access protocols and techniques: Aloha systems, CSMA, IEEE-802 standards, routing and flow control. TCP/ IP protocols, ISDN, ATM, network security, design of a LAN system with commercially available functional units. Wireless LAN: adhoc network, security issues.

Equivalent: ECE F343: Communication Networks

ECOM F366 Lab Project**3****ECOM 367 Lab Project****3**

These courses include projects involving laboratory investigation or laboratory development in the students discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

ECOM F376 Design Project**3****ECOM F377 Design Project****3**

These courses are intended to impart training in design of product/ process or other artifact to the students in the discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

ECOM F462 Network Programming**3 0 3**

Overview of computer networks; inter-process communication; network programming; socket interface; client-server computing model: design issues, concurrency in server and clients; external data representation; remote procedure calls; network file systems; distributed systems design.

Equivalent: IS F462: Network Programming

ECOM F491 Special Project**3**

This is an unstructured open-ended course where under the overall supervision of an instructor-in-charge, batches of students will be attached to different instructors. Each batch will work on a specific time-bound project which is of basic or peripheral concern of his discipline. Each student must submit a project report as a culmination of his endeavour and investigation. The instructor-in-charge will determine the choice of the project and also whether or not the project report is to be submitted jointly by a group or individually by a student. The course will aim to evaluate student's actual ability to use the fundamentals of knowledge and to meet new unknown situations as demonstrated by the students' interaction with the instructors and instructor-in-charge and aggregated in the project report. The instructor-in-charge may assign specific hours for formal brain-storming sessions.

Environmental Engineering**EE G501 Environmental Sampling and Analytical Methods****3 2 5**

Principles of sample collection and data analysis / interpretation, Gravimetric methods, titrimetric methods, electrochemical methods, Spectrometric methods of analysis, Chromatographic methods of analysis, Sampling techniques for air and water pollution, Biological methods of analysis, Interpretation of data in environmental monitoring

EE G502 Water and Wastewater Treatment Systems**3 2 5**

Introduction to water management. Water quality Management and; Assessment: Water and wastewater sources and characteristics, Water quality and effluent standards, Issues related to water supply and disposal of wastewater, General considerations for the source of water for different beneficial uses. Fundamentals of water and wastewater treatment: Water and wastewater collection systems. Considerations for the layout of the treatment plant. Unit operations in water and wastewater treatment plants. Design criteria for units in water and wastewater treatment plants: preliminary, primary, secondary and tertiary treatment units. Household and Small-scale Treatment Systems. Construction and operation of water and wastewater treatment plants. Sustainability Principles in Water Management.

EE G503 Environmental Systems Modelling**3 2 5**

Introduction to air quality models, Atmospheric stability and turbulence, Gaussian dispersion models, single source and multi-source models, Transport and fate of pollutant in aquatic systems, Introduction to modeling of river, lake and estuarine hydrodynamics, Stratification and eutrophication of water bodies, Dissolved oxygen model for water streams, Computational methods in environmental modeling and simulation, Transport and fate of pollutants in soils and ground water, Applications of public domain models and software; Case studies.

EE G504 Physico Chemical Treatment Principles and Design of Wastewater Treatment Systems

Pollutant classification, Source selection process, Selection of treatment chain, Plant siting, Physical treatment methods like screening, sedimentation, filtration, etc., Chemical treatment principles like precipitation, coagulation, ozonation etc., adsorption, Novel processes like membranes, electrodialysis, etc., Design of physico-chemical systems for wastewater treatment, Case studies.

EE G505 Biological Treatment Principles and Design of Wastewater Treatment Systems

Fundamentals of biological treatment, Biochemistry and kinetics of biochemical processes like oxidation, nitrification & denitrification, Dephosphatization, Acidogenesis and methanogenesis, Aerobic and anaerobic treatment processes, Basic description of equipment and design methodologies, Design of reactors and configurations; Case studies for industrial and wastewater treatment.

EE G506 Environmental Statistics**3 2 5**

Introduction to probability and Statistics, Probability concepts and probability distributions, Fundamentals of data analysis, Uncertainty in Measurement, Precision and accuracy, Reproducibility/repeatability, Types of errors, Error propagation, Confidence intervals, Hypothesis testing for equality of mean and standard deviation: t-test, chi-square test and F-test, Errors in hypothesis testing, Experiment design and analysis of variances, Autocorrelation, crosscorrelation and sensitivity analysis in data sets, Linear leastsquares regression. Precision of parameter estimates, Coefficient of determination; Interpreting statistical results, documentation and recommendations, Theory of attributes, Time series analysis, Case studies.

EE G507 Industrial Pollution Abatement**5***

Different types of wastes generated in an industry, their effects on living and non-living things; environmental regulatory legislations and standards and climate changes; quantification and analysis of wastewater and treatment; different unit operations and unit processes involved in conversion of highly polluted water to potable standards; atmospheric dispersion of air pollutants, and operating principles, design calculations of particulate control devices; analysis and quantification of hazardous and non-hazardous solid wastes, treatment and disposal.

EE G508 Urban Water Management**5***

The urban water cycle (description, social imperatives, environmental considerations, and economic challenges); water supply (availability, service levels, and technical options); free basic water, demand management, loss control, use of recycled water; sewage (public health considerations, service levels and technical options, the dryversus-wet sanitation debate, social acceptance, and grey water management); drainage (service levels and technical options, sustainable urban drainage systems (SUDS), urban litter management, urban rivers, risk management, and groundwater issues); management (water sensitive urban design, introduction to asset management, GIS as a water management tool, and sustainability indicators).

EE G601 Energy Generation and Management in Waste Treatment Plants

Energy audit and minimization in waste treatment facilities; Novel energy conservation technologies, Estimation of energy potential of waste; Selection of energy generation technologies coupled

with waste treatment, e.g. incinerators, pyrolysis units, bio-digesters and purification and enrichment of off gases from these units; Utilization of fuel & fertilizer value of gases & liquids from bio-digesters and pyrolysis units; Energy generation from waste sludge.

EE G602 Environmental Remote Sensing and GIS**3 2 5**

Principles of remote sensing, Components of GIS: Hardware, Software and Organization Context, Types of Maps; Spatial and Non Spatial, Types of Projections, Editing the Raster and Vector data structures, Analysis using raster and Vector Data, Data Retrieval, Data Reclassification, Data Overlaying and Buffering; Data Output; Pollution data gathering in GIS area under consideration through terrestrial and aerial stations, unmanned aerial vehicles (UAV) equipped with imaging and spectroscopic probes; Pollution mapping coupled to GIS through wireless network; Water body pollution monitoring instruments coupled to GIS through wireless network, Thermal and microwave remote sensing, Space imaging, Case studies on various applications of GIS for environmental management.

EE G603 Air Pollution Control Technologies**3 2 5**

Introduction to air pollution, Atmospheric diffusion of air pollutants, Particulate control, Gaseous pollutant control, Methods for monitoring and control, Selection and design of control equipments, Meteorological aspects of air pollution, Applications and case studies.

EE G604 Solid Waste Management**3 2 5**

Introduction to solid waste management: Sources and classification, Composition and Properties of Solid Waste and emerging e-waste, Onsite handling, storage and processing including segregation, Collection of solid waste, Transfer and transport, Recycling, Incineration pyrolysis and composting, Processing technique and equipment, Recovery of resources, conversion products, and energy, Biomedical and hazardous waste, Electronic waste, Regulatory framework, categorization, generation, collection, transport, treatment and disposal, Leachate collection and treatment, Bioleaching and bioremediation; Case studies.

EE G605 Environmental Process Engineering**3 2 5**

Origin, Nature and composition of solid, liquid and gaseous emissions from various processes in Industries, institutions and human habitats, Assessment of pollution potential through study of process chemistry and process engineering, Understanding block flow diagrams (BFD), Process Flow Diagrams (PFD) and Piping and Instrumentation Diagram (P&ID) and Process Pollution Flow Diagram (PPFD), Maximum Attainable Control Technologies (MACT) and Best Available Control Technologies (BACT), Reasonably Available Control Technology (RACT) and Lowest Attainable Emission Rate (LAER), List of equipment and processes for BACT/RACT/LAER and their description, Estimating thermophysical and thermodynamic data for pollutants, Use of software in Environmental Process Engineering Equipment design and datasheet generation, Technical audit of Existing process technology, Environmental carrying capacity calculations; Interpretation of field/on-site and laboratory data, Case studies.

EE G606 Environmental Impact and Risk Assessment**3 2 5**

Introduction to Environmental Impact Assessment (EIA), Environmental assessment framework, Impact assessment methodologies; Air and water quality Impact analysis (AQIA / WQIA), Energy and noise impact analysis (EnIA / NIA), Vegetation, wild life and socio-impact analysis, Environment risk assessment, Environmental Impact statement.

Electrical and Electronics Engineering**EEE F111 Electrical Sciences****3 0 3**

Course covers basic passive circuit elements, dependent and independent sources, network theorems, circuit analysis techniques and response of first and second order circuits. Introduction to three - phase circuits, magnetic circuits, transformers, basics of rotating machines. Semiconductors - operation of diodes, zener diodes, bipolar junction transistors and field effect transistors. Biasing techniques and applications of diodes and transistors. Introduction to operational amplifiers and applications. Introduction to Digital Electronics.

EEE F211 Electrical Machines**3 1 4**

Transformer: Constructional features, equivalent circuit and phasor diagram - regulation and efficiency, parallel operation. Three phase transformer connections; Harmonic in transformers; Testing; Phase conversion; Autotransformer. D.C Machines: Construction, armature windings, armature voltage and torque equations, classification. D.C generators, performance characteristics; D.C motors - torque/speed characteristics, speed control and braking. Testing and efficiency. Induction machines: Constructional features and rotating magnetic field. Circuit model and phasor diagram.

Steady state characteristics. Testing, starting and speed control. Time harmonics and space harmonics. Wound rotor induction motors, Single phase induction motors - classification and equivalent circuit. Synchronous machines: Constructional features; synchronous generators and motors; equivalent circuit and phasor diagram; power and torque characteristics and capability curves. Parallel operation. Salient pole synchronous machine - phasor diagram and determination of synchronous reactances; starting and speed control of synchronous motors. Special machines- universal motors, Induction generators.

EEE F212 Electromagnetic Theory**3 0 3**

Review of mathematics - scalar and vector fields, calculus of scalar and vector fields in Cartesian and curvilinear coordinates, Dirac delta function; Electrostatics - electric field, divergence & curl of electric field, electric potential, work and energy in electrostatics, conductors, electric dipole; Electrostatics in Matter - polarization and field of a polarized object, electric displacement, linear dielectrics; Magnetostatics - Lorentz force law, Biot-Savart law, divergence & curl of magnetic field, magnetic vector potential, magnetic dipole; Magnetostatics in matter - magnetization and field of a magnetized object, the H-field, linear & non-linear magnetic media; Electrodynamics - electromotive force, electromagnetic induction, Maxwell's equations in free space, plane wave solutions of Maxwell's equations in free space.

EEE F214 Electronic Devices**3 0 3**

Crystal structure and growth of semiconductor, electrical conduction in solids, Elementary quantum physics (Photoelectric effect, uncertainty principle, Schrodinger wave equation and tunneling), energy bands in solids, charge carriers in semiconductors, excess carriers in semiconductors, Fabrication of p-n junctions, equilibrium conditions, forward and reverse biased junctions, metal-semiconductor junctions Bipolar junction transistors, field effect transistors (JFET, HEMT, MOSFET), Special diodes (varactor diode, solar cell, LEDs, Tunnel diode and HBT), dielectric materials and insulation (Polarization mechanisms, frequency dependence, dielectric strength and insulation breakdown).

EEE F215 Digital Design**3 1 4**

Boolean Algebra & logic minimization; combinational logic circuits : arithmetic circuit design , Design using MSI components; Sequential Logic Circuits : flip flops & latches, registers and counters, Finite state machine ; HDL Implementation of Digital circuits; Digital Integrated Circuits ; Programmable logic devices; Memory organization ; Algorithmic State machine; Introduction to computer organization; The course will also have laboratory component on digital design.

EEE F216 Electronic Devices Simulation Laboratory**0 2 2**

Hands on simulation experience of Electronic Devices (Diodes, BJTs, MOSFET and MOS Capacitor) using Sentarus TCAD; Simulation of electrostatics of various Electronic Devices and their effects on the device performance.

Pre-requisites:

EEE F214 / INSTR F214 / ECE F214 : Electronic Devices

EEE F241 Microprocessors and Interfacing**3 1 4**

Programmers model of processor, processor architecture; Instruction set, modular assembly programming using subroutines, macros etc.; Timing diagrams ; Concept of interrupts: hardware & software interrupts, Interrupt handling techniques, Interrupt controllers; Types of Memory & memory interfacing; Programmable

Peripheral devices and I/O Interfacing ; DMA controller and its interfacing: Design of processor based system. This course will have laboratory component.

EEE F242 Control Systems**3 0 3**

Modeling and classification of dynamical systems, Properties and advantages of feedback systems, time-domain analysis, frequency-domain analysis, stability and performance analysis, State space analysis, controller design.

EEE F243 Signals & Systems**3 0 3**

This course is intended to provide a comprehensive coverage of Signals and Systems, a fundamental subject of Electrical Engineering. The topics covered are: Continuous-time and discrete time signals and systems, convolution, properties of linear time-invariant (LTI) systems, Fourier series, Fourier transform, Z transform, Laplace transform; System analysis, frequency response, analog filters, Sampling and reconstruction.

EEE F244 Microelectronic Circuits**3 0 3**

Basic microelectronic circuit analysis and design, biasing in discrete and integrated circuit amplifiers, an overview of modeling of microelectronic devices single and two transistor amplifier configurations with passive and active loads; current mirrors & current sources; single-ended and differential linear amplifiers , differential and multistage amplifiers; 2 stage CMOS OPAMP, frequency response of amplifiers; negative feedback in amplifiers, R-C frequency compensation.

EEE F245 Control System Laboratory**0 1 1**

Experiments and simulations on concepts related to conventional and advanced control systems.

EEE F246 Electrical and Electronic Circuits Laboratory**0 2 2**

Experiments in Electrical sciences, Electronic devices, motors, transformer windings, machine windings, electronic circuits and signals, systems etc.

EEE F266 Study Project**3**

These courses include projects which are oriented towards readings from published literature or books about new frontiers of development or analysis of available database. These courses are normally available to students in second or higher levels. These courses must coterminate with project reports.

EEE F311 Communication Systems**3 1 4**

Analysis and design of communication systems; analog and digital modulation and demodulation, frequency conversion, multiplexing, noise and distortion; spectral and signal-to-noise ratio analysis, probability of error in digital systems, spread spectrum. Introduction to the basic principles of the design and analysis of modern digital communication systems. Topics include source coding, channel coding, baseband and passband modulation techniques, receiver design, and channel equalization.

EEE F312 Power Systems**3 0 3**

Review and importance of power system, Present power system scenario, Transmission line parameters and modeling, Characteristics and performance of lines, Load flow studies, Optimal system operation, Automatic Generation and voltage Control, Power system fault analysis, Power Systems stability, Introduction of power system protection, Introduction of HVDC Transmission.

EEE F313 Analog & Digital VLSI Design**3 0 3**

Moore's Law, Y chart, MOS device models including Deep Sub-Micron effects; an overview of fabrication of CMOS circuits, parasitic capacitances, MOS scaling techniques, latch up, matching issues, common centroid geometries in layout. Digital circuit design styles for logic, arithmetic and sequential blocks design; device sizing using logical effort; timing issues (clock skew and jitter) and clock distribution techniques; estimation and minimization of energy consumption; Power delay trade-off, interconnect modeling; memory architectures, memory circuits design, sense amplifiers; an overview of testing of integrated circuits. Basic and cascaded NMOS/PMOS/CMOS gain stages, Differential amplifier

and advanced OPAMP design, matching of devices, mismatch analysis, CMRR, PSRR and slew rate issues, offset voltage, advanced current mirrors; current and voltage references design, common mode feedback circuits, Frequency response, stability and noise issues in amplifiers; frequency compensation techniques.

EEE F341 Analog Electronics 3 1 4

Introduction to operational amplifiers: The difference amplifier and the ideal operational amplifier models, concept of negative feedback and virtual short; Analysis of simple operational amplifier circuits; Effects of real operational amplifier parameters on circuit performance. Linear applications of operational amplifiers: Instrumentation and Isolation amplifiers; Current and voltage sources; Active filters. Non-linear applications of operational amplifiers: Comparators; Linearization amplifiers; Logarithmic amplifiers, multifunction modules & circuits, true rms converters, Precision and signal conditioning circuits, Waveform Generation: sinusoidal and non-sinusoidal signal generation; Wave shape converters. Timer 555 based circuits, Phase lock loop circuits & applications, IC regulators, Output stage and large signal amplifiers, Power amplifiers, Tuned amplifiers, Analog and Digital interface circuits: A/D, D/A Converters.

EEE F342 Power Electronics 3 1 4

Need for power conversion; Power electronic converters: classifications and scope; Power semiconductor switches: diodes, SCR, GTO and transistors (BJT, MOSFET and IGBT): Ratings, static and dynamic characteristics, drive and switching aid circuits and cooling; DC to DC conversion: Buck, Boost and Buck-Boost converters: circuit configuration and analysis with different kinds of loads; Choppers: single quadrant and two quadrant operation with DC motor load and steady state analysis; Rectifiers: single phase and three phase operation, power factor, harmonics and effect of source inductance; Dual converters; Drive concept: Four quadrant drive and load characteristics, selection of motor, control and stability of electric drives, feed back control of drives; DC motor drive; Inverters: single phase and three phase bridge inverters and PWM inverters; Single phase AC voltage regulators and cycloconverter; Induction motor drive - Variable frequency operation of 3-phase induction motor, stator voltage control and V/f control methods; Non-drive application of power electronic converters: UPS, active power line conditioner, electronic ballast and induction.

EEE F345 Power Apparatus & Networks 3 0 3

Essential fundamentals of power networks: overview of power systems and changing landscape; sources of electrical energy and environmental consequences; the Indian power industry; fundamental principles of power networks; magnetic prerequisites. Apparatus in power networks: transformers; synchronous generators; transmission lines, cables, HVDC; loads and power quality. Analysis and operation: power flow; rotor angle and voltage stability; control of large interconnected power networks. Protection: fault calculations, relay co-ordination and circuit breakers; transient overvoltages, protection by surge arrestors, and insulation co-ordination. Management of vertical utilities, utility deregulation and open access: operational economics of the power industry, privatization; deregulation and energy markets.

EEE F346 Data Communication Networks 2 0 2

Communication Concepts; Data and Voice Communications; Hardware Systems and Configurations; Network Topologies and Design Aspects; Protocols; Networking Software; Local Area Networks; Network Security and Management; Emerging Trends in Communications.

EEE F347 Communication Networks Laboratory 0 2 2

Experiments on analytical studies of communication networks through network simulation, analysis of network performance, LANs, Cellular or Satellite networks, Wireless Adhoc or Sensor Networks, Wi-Fi and WIMAX networks, information theory and coding etc.

EEE F348 FPGA Based System Design Laboratory 0 2 2

Introduction to Field Programmable Gate Arrays, Overview of FPGA design tools, Implementation of Data Flow Graph in FPGA,

Analysis of performance tradeoffs (Pipelining, Retiming, Unfolding), Bus protocols (SPI, I2C), FPGA based DSP System Design, ADC/DAC interface, Real time signal processing system design.

EEE F366 Lab Project 3

EEE F367 Lab Project 3

These courses include projects involving laboratory investigation or laboratory development in the students discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

EEE F376 Design Project 3

EEE F377 Design Project 3

These courses are intended to impart training in design of product/ process or other artifact to the students in the discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

EEE F411 Internet of Things 3 1 4

Introduction to IoT, Sensors and Actuators for IoT, Programming IoT end points, Communications and networking in IoT, Data management in IoT, Security issues in IoT, Emerging technologies.

EEE F414 Telecommunication Switching Systems & Networks 3 0 3

Introduction, electromechanical switching, pulse dialing and DTMF dialing, stored program control, space division switching, speech digitization and transmission, time division switching, fundamentals of traffic engineering, telephone networks, signaling, data networks, layered architecture and protocols, LANs, packet switching networks, TCP/IP, ISDN, ATM networks.

EEE F416 Digital Communication 3 0 3

Introduction, the modeling and characterization of information sources, algorithms for source coding and encoding of analog output sources; Information transmission through AWGN channels using digital modulation methods and BER estimation; Digital communication through band limited Gaussian noise channels; channel coding and decoding; Wireless communication channels: its characterization and modulation schemes for such channels; emerging trends in the above field.

EEE F417 Computer Based Control Systems 3 0 3

Introduction to process control and Computer based control, elements of computer based control loop, digital sensors and their applications, field buses and specifications, types of digital and intelligent controllers, types of industrial control valves and their selections, PID vs Fuzzy and Neural Techniques of control, programmable logic controllers, SCADA and its applications, distributed control systems comparison between PLC, DCS, Fuzzy. ANN, industrial network hierarchy, industrial standards for networking, application of PLC in power system and process industries.

EEE F418 Modern Communication Technologies 3 0 3

Modern communication systems overview, Digital modulation techniques, Channel capacity and coding, Digital link improve techniques, Digital receiver design and performance analysis, Wireless communication systems: wireless channel models and link improvement techniques, multiple access schemes. Basic concept of mobile network, Optical Communication Systems: Transmitters, receivers and other optical Communication subsystem, Optical wireless systems.

EEE F419 Flexible and Stretchable Electronics 3 1 4

Introduction to flexible and stretchable electronics (FSE), material systems and scaling issues; materials and substrates for flexible and printed electronics, Material Considerations and various properties, techniques for fabrication and characterization of FSE devices, mechanics of thin-films and flexible devices, various flexible and stretchable devices: solar cells, displays, thin-film transistors, sensors, artificial skin and actuators; human-machine interfaces, wearable electronics for emerging applications.

Pre-requisite: EEE/INSTR/ECE F214: Electronic Devices

EEE F420 Biomedical Signal Processing 3 1 4

Introduction to biomedical signals and images, fundamental and advanced filtering techniques for artifacts removal, event detection, feature extraction of the biomedical signals, Homomorphic filtering, modeling biomedical signals and systems using pole-zero modeling and all-pole modeling, cochlear signal processing, deep learning and stochastic decision-making approach for diagnostic decisions, various case studies of biomedical signals for artifact removal and event detection will be discussed.

Pre-requisite: EEE F434 or ECE F434 : Digital Signal Processing

EEE F422 Modern Control Systems 3 0 3

State variable characterization of linear continuous - time and discrete - time systems, controllability, observability, stability; sampled data systems; Z transforms; non-linear systems; phase plane and describing function methods; calculus of variations; optimal control.

EEE F423 Electronic Material Design and Simulations 1 2 3 Laboratory

Reviewing the basic Theory for Crystalline Solids (Crystal group, real Space, reciprocal space), Introduction of the Concept of Density Functional Theory (Many Electron Scenario, Born-Oppenheimer Approximation, Hartree's Formulation, Hohenberg and Kohn Theorems, Energy Functional, Kohn Sham Scheme), Familiarization with Quantum Espresso (Plane Wave Basis Set, Exchange Correlation Functional, Pseudopotential, Brillouin Zone Sampling, Quantum Espresso input file format), Theoretical Calculation of Structural Properties of Materials (Unit Cells and Super Cells, Lattice Vectors, Ground-state Energy, Bond-Length and Bond Angles), Theoretical Calculation of Electronic Properties of Materials (Energy Band Profiles and Density of States, Projected Density of States), Theoretical Calculation of Optical Properties of Materials (Optical Spectrum), Introduction of Doping in Materials (Effects on Electronic and Optical Properties), Introduction of Strain in Materials (Effects on Electronic and Optical Properties) Simulation of 2D materials like Graphene and MoS₂.

Pre-requisites:

EEE F214 / INSTR F214 / ECE F214 : Electronic Devices

EEE F424 Smart Grid for Sustainable Energy 3 0 3

Introduction to Smart grid, Renewable Power Generation and Energy Storage, Microgrid, Power System Economics and Electricity Markets, Demand Response, Various Sensing, Communication, and Control technologies, and Application of Data Science.

Pre-requisite:

EEE F242 / INSTR F242 / ECE F242 : Control Systems

EEE F425 Power System Analysis and Control 3 0 3

Course description is to be developed.

EEE F426 Fiber Optics & Optoelectronics 3 0 3

Theory of optical fibres; image transmission by fibres; technology of fibre production; fibre testing; characterization of optical fibres; detectors and sources for fibre optic systems; active fibres; applications of optical fibres; optoelectronic devices and applications.

EEE F427 Electric Power Utilization and Illumination 3 0 3

Introduction to industrial utilization of electric power, types of drives, its characteristics, insulation materials used, Industrial applications such as electric heating, welding etc., traction systems, DC and AC systems of railway electrification, Train movement and factors effecting Energy Consumption, Speed-time curve, Tractive effort, Power of traction motors. Braking systems, Regenerative braking, Mechanical braking, control equipments. Illumination, laws of illumination, lighting calculation, interior and exterior illumination systems, design of various lighting schemes, types of lamps, high or low pressure lamps and discharge tubes.

EEE F428 Energy Storage Systems

3 0 3

Need of Energy Storage; Broad classification of Energy Storage Systems and applications; Electrochemical Energy Storage Systems; Battery Storage; Application oriented choice of Batteries; Electrical interface system design for Batteries with Renewable Energy sources; Battery Management Systems (BMS); Hydrogen Energy Storage; Its application as Fuel cell, Electrical Energy Storage; Thermal Energy Storage; Mechanical Energy Storage and their applications.

EEE F429 Smart Materials and Applications 3 1 4

Basics of Piezoelectric Materials, constitutive relationship, electromechanical coupling coefficients, piezoelectric constants, polyvinylidene fluoride, piezoelectric composites and also design of sensors & actuators using piezoelectric materials. Shape Memory Alloys: Phase Transformations, Basic Material Behaviour, Properties of SMAs for Biomedical Applications, SMA based actuators and sensors. Composition and properties of MR fluid & ER fluids, applications of ER and MR fluids in active vibration control and damping. Magnetostrictive, Electrostrictive materials, Magnetic Shape Memory Alloy, Ionic Polymer Metal Composites and micro electro mechanical systems (MEMS) using smart materials.

EEE F430 Green Communications and Networks 3 0 3

Need for Green radios, Sustainable development goals (SDGs), Historical developments, Fundamental trade-offs, Practical constraints, End-to-end green communication system, Energy harvesting (EH) components, Physical layer (PHY) of Green communication network, Wireless power transfer (WPT), Simultaneous wireless information and power transfer (SWIPT), energy efficiency optimization of PHY, Green wireless network architectures, green cooperative and spectrum sharing networks, Green sensor networks, EH-Internet of things (EH-IoT), Energy-efficient protocols, Big data management in green IoT, Introduction to green UAVs, Current trends in green communication networks, Game theory perspectives, Artificial intelligence (AI) uses for green communications.

Pre-requisite:

EEE F311: Communication Systems

EEE F431 Mobile Telecommunication Networks 3 0 3

Fundamentals of mobile telecommunications, with an overview of first generation (analog) systems and more detailed coverage of second generation (digital) technologies; technology basics including descriptions of wireless network elements, spectrum allocation, frequency re-use, characteristics of the transmission medium; over the-air (OTA) interface characteristics; capacity, coverage, speech coding, channel coding and modulation techniques of TDMA and CDMA technologies; network characteristics; architecture, signaling, element management of IS-41 and GSM networks; call processing; call setup and release, handoff, roaming, advanced services; mobile data communications; circuit and packet switched data services, third generation (wideband data) mobile communications system requirements/ architecture.

EEE F432 Medical Instrumentation 3 0 3

Basic components of bio-medical instruments, bio-electric signals & recording electrodes, transducers, recording and display devices. Patient care and monitoring systems, cardiovascular measurements-blood pressure, blood flow, cardiac output, heart sounds etc.; instrumentation for respiratory and nervous systems, analysis of EEG, ECG, EMG, EOG and action potentials, non-invasive diagnostic measurements - temperature, ultrasonic diagnosis, CAT scan techniques, sensory measurements-motor response, analysis of behaviour etc. biotelemetry, biofeedback, clinical laboratory instruments, X-ray diagnosis. Recent advances in biomedical instrumentation- microprocessor based systems, lasers & optical fiber based systems.

EEE F433 Electromagnetic Fields & Waves 3 0 3

Maxwell's equations; application of circuit theory and field theory; Maxwell's equations in free space and time varying fields; plane waves in dielectric and conducting media; solution of wave equations; the poynting vector; the poynting theorem; poynting vector

in conducting media and circuit application; wave polarization; linear, elliptical and circular polarization; wave reflection, refraction and diffraction; transmission lines and resonators; Smith chart, and its applications in stub matching and impedance matching; discontinuities; antennas and radiation; halfwave dipole antenna; loop antenna; helical antenna; directive arrays; frequency independent antennas; reflector and lens antennas; horn antennas; antenna arrays; Friis formula; antenna practices and antenna measurements.

EEE F434 Digital Signal Processing 3 1 4

Introduction; design of analog filters; design of digital filters (IIR and FIR); structures for the realization of digital filters; random signals and random processes; linear estimation and prediction; Wiener filters; DSP processor architecture; DSP algorithms for different applications.

EEE F435 Digital Image Processing 3 0 3

Introduction to multidimensional signal processing-- 2-D convolution and filtering, discrete-time Fourier, filter design 2-D sampling and reconstruction transform, human visual system, Brightness perception, Temporal properties of vision, 2-D Block transforms- Walsh-Hadamard, Karhunen Loeve, Discrete Hartley, Filter Banks and Wavelets etc., Image Compression, Image Enhancement, Medical Image Processing, 3D techniques.

EEE F436 Electromagnetic Compatibility 3 1 4

Basic concepts of EMI/EMC – sources, units, coupling, issues and regulation, Electrical signals and spectral properties, Time and frequency relations, Measurement, Behavior of electrical circuits, Self and mutual impedances, Transmission lines and signal integrity, Non-ideal behavior of wires and lumped components, Emission and Susceptibility –conducted and radiated, Emission models – common mode and differential, Measurement of emissions, System design for EMI, High speed circuit boards, Electrostatic discharge, Cross-talk, Three conductor transmission lines, Grounding, Shielding, Cabling, Filtering, Decoupling, Other EMI related issues.

EEE F437 Semiconductor Fabrication Technology 3 1 4

Semiconductor Fabrication: Process Flow; Crystal structures, defects, directions, planes; Single crystal growth to Wafer preparation, dopant distribution; Oxidation and Si/SiO₂ interface; Lithography; Doping Process Dopant Diffusion (Doping process); Ion Implantation (Doping process); Annealing of damages and masking during implantation; Thin Film Deposition; Etching; Metallization; Emerging techniques

Pre-Requisites: ECE F214 / ECOM F214 / EEE F214 / INSTR F214 : Electronic Devices

EEE F462 Advanced Power Systems 3 0 3

Symmetrical components, sequence impedances; fault calculations; short circuit studies; circuit breakers and their selections; power system stability, power system protection--generators, transformers and lines; waves on transmission lines, protective devices -- grounded and ungrounded systems.

EEE F472 Satellite Communication 3 0 3

Review of microwave communications and LOS systems; the various satellite orbits like GEO, MEO, LEO; the satellite link analysis and design; the communication transponder system like INSAT, INELSAT etc; the earth segment and earth station engineering; the transmission of analog and digital signals through satellite and various modulation techniques employed; the multiple access techniques like FDMA, TDMA, CDMA, DAMA, etc; the INSAT program; salient features of INSAT – systems and services offered; satellite services offered by INTELSAT, INMARSAT and future satellites like IRIDIUM etc; future trends in satellite communications.

EEE F473 Wind Electrical Systems 3 0 3

Thermodynamics of wind energy, Types of Wind energy conversion devices, Aerodynamics of wind rotors, design of wind turbine rotor, Power -speed characteristics, torque-speed characteristics, Wind turbine control systems, Wind speed measurements, Wind speed statistics, Site and turbine selection, Induction Generators,

Wound field synchronous Generator, Permanent Magnet synchronous machine, Doubly fed induction generator, Power Flow equations, Power Semiconductor devices, Converters, Inverters, power quality, Reactive power compensation, Wind diesel hybrid systems, Wind photovoltaic systems, Role of Govt. and policies for market development.

EEE F474 Antenna Theory and Design 3 1 4

Introduction into antenna theory and practice, Radiation integrals and auxiliary potential functions; basic EM theorems in antenna problems, Antenna characteristics, Infinitesimal dipole; wire and loop radiating elements, Wire antennas – dipoles, monopoles, Arrays – analysis and design, Reflector antennas, Broadband antennas, Micro-strip patch antennas, Smith Chart Review in line with antenna theory and Design, Antenna measurements, Antenna design using commercial software, study of radiation pattern of various antennas.

EEE F475 Special Electrical Machines 3 1 4

Construction, principle of operation and performance of synchronous reluctance motors, stepping motors, and switched reluctance motors, permanent magnet brushless D.C. motors, permanent magnet synchronous motors.

EEE F476 Switchgear and Protection 3 1 4

Working applications of various switchgears and protective elements. Switches and fuses, Elementary principles of Circuit Breakers, Description and Operation of different types of circuit breakers, Electromagnetic and Static Relays, operation, construction and characteristics, Generator Protection, Transformer Protection, Feeder and Bus-Bar Protection, Neutral Grounding, Protection against over voltages.

EEE F477 Modeling of Field-Effect NanoDevices 3 0 3

Physical principles and MOS transistor phenomena, developing models including effective mobility, temperatures effects, and source/drain resistances. small-dimensional effects, impact ionization, velocity saturation drain-induced barrier lowering (DIBL), ballistic operation, polysilicon depletion, quantum effects, gate-tunneling currents, gate-induced drain leakage (GIDL), fundamentals of low-power (low-voltage) CMOS design issues; the threshold voltage shift (due to SCE), increased leakage power, sources of power, SOI MOS, (PDSOI, FDSOI), multigate (MG) MOSFET, electrostatic integrity and short channel control, quantum mechanical origin, basics of BSIM CMG, compact models for multigate MOSFETs, mobility in multiple gate devices, improvement of the mobility, crystallographic orientations, strained Si channels.

EEE F478 Power Systems Laboratory 0 2 2

Experiments on relays, circuit breakers, transmission lines, switch gear and protection, energy generation methods, and application of artificial intelligence techniques, electric energy utilization including illumination, electrical drives etc.

EEE F491 Special Projects 3

This is an unstructured open-ended course where under the overall supervision of an instructor-in-charge, batches of students will be attached to different instructors. Each batch will work on a specific time-bound project which is of basic or peripheral concern of his discipline. Each student must submit a project report as a culmination of his endeavour and investigation. The instructor-in-charge will determine the choice of the project and also whether or not the project report is to be submitted jointly by a group or individually by a student. The course will aim to evaluate student's actual ability to use the fundamentals of knowledge and to meet new unknown situations as demonstrated by the students' interaction with the instructors and instructor-in-charge and aggregated in the project report. The instructor-in-charge may assign specific hours for formal brain-storming sessions.

EEE G510 RF Microelectronics 5

Introduction; application of RF electronics in modern systems; basic concepts in RF circuit design, active RF components: various RF diodes and transistors and their circuit models, matching and biasing networks, RF amplifier design: low power, low noise

and broadband amplifiers, RF oscillator design; negative resistance oscillator; dielectric resonator oscillators, phase noise. RF Mixers: Balanced mixers; low noise mixers; noise in RF circuits, microwave transmitters and receivers.

EEE G511 Integrated Electronics 3 2 5

Review of basic semiconductor devices and ICs, fabrication and design of integrated circuits, comparison of current bipolar and MOS technologies, VLSI design methodology and layout examples, etc. The main objective of this course is to enable the students to keep pace with the rapidly changing semiconductor technology.

EEE G512 Embedded System Design 3 1 4

Introduction to embedded systems; embedded architectures: Architectures and programming of microcontrollers and DSPs. Embedded applications and technologies; power issues in system design; introduction to software and hardware co-design.

EEE G513 Machine Learning for Electronics Engineers 4*

Machine Learning approaches - supervised, unsupervised, semi-supervised, and reinforcement learning. Multi-Layer Perceptron, Convolutional Neural Networks, Recurrent Neural Networks, Generative Deep learning, Deep learning techniques and their application to various types of electronic systems/subsystems such as control-dominated systems, NLP systems, vision-based systems, communication systems, embedded systems and IoT systems. Multi-modal and Multi-task learning, Transfer learning, challenges in the implementation of ML techniques, complexity analysis of the ML architectures for hardware implementation, efficient architectures/ topologies for ML implementation, Hardware Platforms, Tools, and Software Packages for ML.

EEE G514 Nanoelectronic Memories and Technology 3 2 5

Introduction to memory devices in SRAM, DRAM and 3DNAND Flash, circuit and device considerations, device fabrication techniques and scaling avenues, memory array addressing, readout circuits, device characterization, reliability characterization. Non-volatile memory cell structures like (1T-1C 6T, 4T, 1T-1R, 0T-1R, 1S-1R, floating gate FLASH, SONOS, NROM), and memory organization (open bit-line, folded bit-line, NAND, NOR, cross-point etc.), new memory devices and concepts including (e.g. magnetic tunnel junction memory (MRAM, SST-RAM), ferroelectric memory (FRAM), phase change memory (PCM), metal oxide resistive switching memory (RRAM), nanoconductive bridge memory (CBRAM)

Pre-requisites:

EEE F214: Electronic Devices OR EEE F313: Analog and Digital VLSI design OR MEL G621: VLSI Design OR MEL G631: Physics and Modelling of Microelectronic Devices

EEE G520 Wireless and Mobile Communication 3 2 5

Signal propagation in a mobile environment, modulation, coding, equalization; first generation generation systems; multiple access techniques like FDMA, TDMA, CDMA, spread spectrum systems; second & third generation systems, UMTS, IMT-2000; Wireless LAN, Wireless ATM and Mobile IP; emerging trends in Wireless & Mobile Communication.

EEE G521 Optoelectronic Devices, Circuits & Systems 3 2 5

Physics of optical radiation and principles of calculation in radiation physics & optics, fundamental laws of photometry. Interaction between optical radiation and matter. Radiation sources. Parameters of IR detectors and junction photodetectors, parameters common to emitters and receiver, radiation measurements, optoelectronic components, optoelectronic integrated devices, photodetector circuits, methods of modulation and optoelectronic system design and applications.

EEE G522 Advanced Satellite Communication 5*

Radio wave propagation effects, low, medium and geo-synchronous earth orbits and their main characteristics. Various sub-systems of the satellite, the outer space and its impact on the design of spacecraft subsystems, LEO satellite network and its routing calls; Battery technology, propagation loss models, modulation

and error correction techniques, Digital Video Applications, Satellite Mobile including NGE0, satellite access techniques, third generation satellite communication, remote sensing, bandwidth utilization and throughput capability, the Indian National Satellite System (INSAT), INTELSAT and other international satellite programs, VSAT, Mobile and Personal Satellite communication, principles of Global Positioning System (GPS), GPS receivers and its applications, regulatory and interference issues. Study and design of uplink transmitter, down link receiver, spacecraft transponder, satellite communication links.

EEE G531 Testable Design and Fault Tolerant Computing 3 2 5

Fault: types, modelling and simulation; testing methodologies, coverage, economics and quality; test vector generation: design for testability, built-in self tests; fault tolerant computing; fault tolerant software.

EEE G541 Distribution Apparatus and Configurations 3 2 5

Basic configuration of a distribution set-up at the consumer end. Transformer types, specifications, performance, protection, and sizing. Types of cables and insulation, cable parameters, ampacity and protection. Ratings of LV switchgear and their use in selection, switching transients and clearing time. Properties of fuses with reference to ampacity. Meters, instrument transformers, and their application. Voltage control at distribution levels. Elementary concepts of power quality: power factor, frequency, and harmonic content.

EEE G542 Power Electronic Converters 3 2 5

The importance of the converter as an interface between source and load. DC-DC converters: Buck, boost, and buck-boost configurations. AC-DC converters: Diode and thyristor converters in single and three phase. Inversion in thyristorised converters and applications of line commutated inverters. DC-AC converters: Switch mode voltage source inverters in single and three phase, PWM operation of different types, VSI's operating in multi-levels, space vector modulation techniques. AC-AC converters: Thyristor fed AC loads, the cycloconverter. Matrix converter arrays and their operation as DC-DC and DC-AC converters.

EEE G543 Power Device Microelectronics and Selection 3 0 3

Thermal features of power device packaging, the issues of $R_{\theta JC}$ and $R_{\theta CS}$, heat flow and effect on device temperature, heat sink design and selection. The two-layer junction behaviour, the concept of drift region, characterisation of power diodes. The base operation in a thick film BJT, steady state characteristics, turn ON and turn OFF times, the multistage power Darlington. The four-layer junction behaviour, two transistor model of a thyristor, dynamic model for a four layer junction device. GTO thyristors, the turn OFF mechanism in four layer junction devices, current technological problems. MOS operation and characteristics, characterisation and structure of the power MOSFET. Development of the MOSFET to IGBT, technological advantages, characterisation, and dynamic behaviour. Current technological problems in insulated gate technologies. Introduction to matrix converters.

EEE G544 Steady State and Dynamics of Electric Motors 3 2 5

Direct current machines, dynamic characteristics of PM and shunt DC motors. The Reference Frame theory, balanced steady state phasor relations and voltage equations. Symmetrical induction machines: commonly used reference frames and per-unit system, analysis of steady state and dynamic operation and free acceleration characteristics from different reference frames. Synchronous machines: equations in different reference frames, per-unit system, steady state analysis, dynamic analysis for load changes and faults. Brushless DC machines: voltage and torque equations in machine variables, and rotor reference frame variables, analysis of steady state and dynamic performance. Operational impedances and time constants for synchronous machines. Linearised machine equations, and reduced order machine equations. Symmetrical and asymmetrical two-phase induction machines: conversion to stationary reference frame,

analysis of steady state operation of the asymmetrical machine, single phase induction machine.

EEE G545 Control and Instrumentation for Power Electronic Systems 3 0 3

The regulation and control problem with reference to power electronic converters. Converter models for feedback: basic converter dynamics, fast switching, piece-wise linear models, discrete-time models. Voltage mode and current mode controls for DC-DC converters, comparator based control for rectifier systems, proportional and proportional-integral control applications. Control design based on linearisation: transfer functions, compensation and filtering, compensated feedback control systems. Hysteresis control basics, and application to DC-DC converters and inverters. General boundary control: behaviour near a boundary, and choice of suitable boundaries. Basic ideas of fuzzy control techniques, and performance issues. Sensors for power electronic circuits, speed and torque transducers.

EEE G546 Systems Simulation Lab. 4

Simulation tutorial problems on single- and three-phase AC-DC converters, DC-DC buck-, boost-, and buck-boost converters, DC-AC inverters in single and three phase with different levels of control complexity. Simulation of practical applications from utility and drives. May also include a small project.

EEE G547 Device Drivers 3 2 5

Introduction to operating system, Introduction to Linux Basics, commands, file system, kernel and introduction to Android, Process Synchronization, Semaphores, Message Passing, Mailboxes and debugging, Module programming/ Shell programming / Character Device Driver, Timing and Interrupts--, Device Driver Programming as applicable to Linux/ Android/ Windows, Parallel/ Serial Port Driver/ Block /USB /NETWORK/ PCI/ Drivers, tty Sub-system

EEE G552 Solid State Drives 3 2 5

Introduction to the drive system: requirements, components and benchmarks; Review of motor theory; Power electronic control of motors: requirements and operational issues; Static speed control of induction motors: the AC power controller, slip energy recovery, VSI and CSI controlled induction motors; Speed control of synchronous motors and associated machines; The problem of DC motor speed control: rectifier and chopper controllers; Advanced induction motor drive control: vector control, current modulation, importance of microcontroller based systems; Organisation of microcontrollers: sensing and actuation of signals, interrupt handling and timing, priority of tasks in a microcontrolled drive system.

EEE G553 Utility Applications of Power Electronics 3 0 3

Static excitation systems: converters as used in SES, control and the IEEE types, enhancement of stability. HVDC transmission: configurations of line-commutated converters, constant current and constant extinction angle control at device terminal level, individual phase and equidistant pulse firing control at device level, active and reactive power considerations. FACTS: impedance type and inverter type FACTS devices, the static var compensator, the thyristor controlled series reactor, the STATCOM and its developments in the form of UPFC and SSSC. Active filters: the power quality problems at distribution level, inverter control by transient p-q theory, configuration of active filters and their control, existing bottlenecks.

EEE G554 Soft Switching Converter Technologies 3 0 3

Series, parallel, series-parallel resonant DC-DC converters, half and full bridge topologies, analysis and design. Sinusoidal analysis of resonant converters, soft switching, load resonant properties, exact characteristics. Soft switching mechanisms of semiconductor devices, zero current and zero voltage switching quasi resonant converters, resonant switch topologies, soft switching in PWM converters and inverters, multi resonant converters, control of resonant and soft switching converters, EMI suppression, snubbers, load resonant converters, passive components at high frequencies.

EEE G555 Transformer and Motor Design 3 0 3

Course description for the above course is to be developed.

EEE G556 DSP Based Control of Electric Drives 3 0 3

State space and transfer matrix representations, representation of nonlinear systems by update of parameters, output feedback and state feedback control, basic notion of state estimation. Sampling of signals, discrete representation of signals, z-transforms. Nature of discrete time poles and zeros. A/D and D/A converters as system elements. FIR and IIR behaviour, noise and its nature. AR, MA, and ARMA models of systems. The Fourier transform and what it conveys. Processing requirements of a DSP, floating point DSP's: the TMS320C3x family. Memory organisation, interrupt systems, and I/O interface with the TMS320C3x family. The TMS320C31 as an embedded controller, drive control features. Applications in vector and direct torque control of synchronous motors, vector and direct torque control of induction motors, torque control of SRM's.

EEE G557 Drives for Electronic Transaction 3 0 3

Course description is to be developed.

EEE G558 DSP Based Implementation Drivers 3 0 3

Course description is to be developed.

EEE G559 Advanced Power Electronics 5

Qualitative, Quantitative, and Simulation studies of Power electronic circuits like AC to DC, DC to DC, DC to AC and AC to AC converter circuits for their theory, performance, design, testing and applications. Use of these circuits for industrial, motor control, FACTS, HVDC, PF improvement and energy conservation applications.

EEE G581 RF & Microwave Engineering 3 2 5

Introduction to radio frequency engineering; advantages; various frequency bands; propagation; transmission lines; microwave waveguides and components; their characterizations; s-parameters and their use; microwave transistor; FETs, Gunn diode, IMPATT diodes; microwave tubes; Klystron; two cavity Klystron amplifier analysis; reflex Klystron; TWTs; high power tubes; cross field tubes; microstriplines; MMICs; microwave measurements; microwave antennas and microwave communication system; microwave applications; ISM applications; introduction to EMI and EMC; microwave hazards.

EEE G582 Telecom Network Management 5

Network architecture and protocols; LAN, MAN and WANs; inter-networking; network planning; network management concepts and standards; administrative, operational and fault management; security issues; remote network management.

EEE G591 Optical Communication 3 2 5

Optical communication systems and components; optical sources and transmitters (basic concept, design and applications); modulators (electro-optic, acousto-optic and laser modulation techniques); beam forming; focussing and coupling schemes to optical repeaters; optical amplifiers; optical field reception; coherent and non-coherent lightwave systems; fibre optic communication system design and performance; multichannel lightwave systems; long haul communications; fibre optic networks.

EEE G592 Mobile & Personal Communication 3 2 5

History of mobile radio; the mobile radio signal environment; review of statistical techniques; pathover flat as well as hilly terrain; effects of RF system design on propagation; received signal envelope and phase characteristics; modulation schemes employed; functional design of mobile radio systems, diversity schemes-space; frequency and polarization diversity; mobile radio system functional design; signal error analysis versus performance criteria; multiple access schemes; classification of the concepts of sensitive topics; new concepts data transmission via cellular; spectrum and technology of WLL.

EEE G593 Power Quality 5

Power Quality Introduction and terms and definitions, Voltage sags and interruptions, Transient Over Voltages, Fundamentals of harmonics, Harmonic Solutions, Long duration voltage variations, Distributed generation and power quality, Wiring and grounding, Power quality monitoring.

EEE G594 Advanced VLSI Devices 5

Device physics of and engineering of advanced transistors, review of metal oxide semiconductor (MOS) with quasi-ballistic and ballistic transport, Short-channel effects (SCEs) in nanometer regime, scaled MOSFETs, Device physics and engineering of sub-100nm MOSFETs, Limits of the state-of-the-art silicon device technology, issues in the miniaturization, Alternative device structures, non-conventional MOSFETs, and transport in novel nanodevices. Analytical expression (supported by TCAD simulation) for the one-dimensional transport and interpretation of novel device characteristics.

EEE G595 Nanoelectronics and Nanophotonics Technology 5

Semiconductor Fundamentals, Band Theory, Quantum Structures and Quantum Mechanics, Transport in Quantum Structures, Optical Properties of Semiconductor Quantum Structures, Strain Engineering, Electro- Optic Effects, Photonic / electronic Devices based on Nano structures.

EEE G611 Computer Aided Analysis and Design 3 2 5

The course aims at developing complete self reliance in solving analysis & design problems of engineering with the aid of computers. It stresses upon the use of more powerful tools including system planning, simulation and modelling. The student will take up a design project and will work independently on the project guided by the instructor or resource person as and when required. The effort must culminate with a CAAD program and a project report.

EEE G612 Coding Theory & Practice 3 2 5

Codes for data-compression: instantaneous codes; Kraft inequality; Mcmillan theorem; Huffman codes; codes for error-detection and correction; binary symmetric channel; channel capacity, Shannon's fundamental theorem; linear codes; Macwilliam's identity; Reed-muller codes; cyclic codes; BCH codes; codes for secrecy and security; private-key cryptosystems; affine codes; twisted codes; one-time-pads; public-key cryptosystems based on large primes and discrete logarithms.

EEE G613 Advanced Digital Signal Processing 5

Review of stochastic processes, models and model classification, the identification problem, some field of applications, classical methods of identification of impulse response and transfer function models, model learning techniques, linear least square estimator, minimum variance algorithm, stochastic approximation method and maximum likelihood method, simultaneous state and parameter estimation of extended kalman-filter, non-linear identification, quasi linearization, numerical identification methods.

EEE G614 Advanced Wireless Communications 3 2 5

Evolution of wireless cellular technologies to 5G and beyond, review of matrix and signal theory for communication applications, introduction to stochastic geometry for performance analysis of wireless networks, D2D communications- modeling and analysis, cooperative communications-buffer-aided relaying and performance analysis, modulation and multiple access techniques-NOMA, OTFS, OAM. Introduction to potential technologies for beyond 5G/6G communications: IRS, molecular communications, and AI in wireless communications.

Pre-requisite:

EEE F311: Communication systems

EEE G621 Advanced Electronic Circuits 3 2 5

Linear and non-linear operational circuitry, controlled sources, Active filters, power amplifiers, Power supplies, Analog switches and comparators, combinational and sequential logic circuitry. Data

transmission and display, Electronic Controllers, Transducer interfacing and measurement circuits, etc.

EEE G622 Advanced Digital Communication 3 2 5

Introduction to Digital communication, review of probability and statistic processes; review of source coding and characterization of signals; optimum receivers for additive white gaussian noise channel; carrier & symbol synchronization; channel capacity & coding; block & convolutional codes; communication through band – limited linear filter channels; adaptive equalization multi-carrier systems; digital communication through fading multipath channel; future trends in digital communication.

EEE G625 Safety Critical Embedded Systems Design 4

Course description is same as given under HTSL ZG631.

EEE G626 Hardware Software Co-Design 4

Course description is same as given under HTSL ZG641.

EEE G627 Network Embedded Applications 3 1 4

This course deals with the three main application areas of Network Embedded Systems – Wireless Sensor Networks, Automotive Networks, and Industrial Networks– Network Architecture, Deployment Issues, Network Protocol stack: Modular and Cross Layer Design. Network Node: Architectures, Operating System and Applications. Middleware Issues and Design. Security and Encryption

EEE G641 Applied Estimation Theory 3 2 5

Review of random processes, linear algebra and matrix theory, ML phase and timing estimation in digital communication, Scalar estimation, estimation in real and complex vector space, Study of performance degradation due to estimation errors, Frequency diversity and equalization, Study of MLSE for equalization, Estimation of Single Input-Single Output (SISO) channel to very complex Multi Input-Multi Output (MIMO) channels, study of different estimators such as MMSE, linear MMSE, orthogonal frequency division multiplexing (OFDM) basics, OFDM channel estimation, Channel quality estimation, Impact of channel estimation errors on performance, Introduction to WLAN standards, IEEE 802.11n, channel estimation, MATLAB experiments and projects.

English**ENGL G511 Growth of the English Language 5**

The Origin and development; old English, middle English and modern English; foreign influences; changes in grammar and phonology; rise of standard English; English in the international context.

ENGL G512 Language and S & T 5

Historical development of communication in science; communicative process in science and technology; language of science & technology; scientific literature; growth and role of scientific journals.

ENGL G513 Social Impact of S&T 5

Elements of scientific thinking; role of science and technology in social change; impact of science on environment; technology and social growth; impact of science & technology in terms of developments in transportation and communication and innovations in sources of energy; impact on the quality of life.

ENGL G521 Principles of Language Teaching 5

Teaching different language skills; grading; sequencing and presentation; teaching at different levels; remedial teaching; techniques of teaching comprehension, grammar, composition; lesson planning; syllabus design; testing.

ENGL G522 Aesthetics and Technology 5

Aspects of aestheticism; emergence of aestheticism; influence of aesthetics on technology; impact of technological explosion on human sensibility and its expression in selected art forms.

ENGL G531 Applied Linguistics 5

Linguistics and language teaching; contrastive linguistics and its applications; error analysis; a linguistic theory of translation; linguistic approach to literature.

ENGL G541 Interpretation of Literature 5

Literary forms and conventions and their development; different critical approaches; practical criticism.

ENGL G551 Information Technology Lab I 5

(This course is specially designed to prepare the stream of input, viz. traditional English graduates, in the use of technology in communication).

This course is built around the theme of use of modern technology for the purpose of presentation and processing of information for effective communication within an organisation. Consistent with this theme, assignments would be drawn from the student's work environment and from one or more areas of the following: Computerized text processing; use of utility software packages for information processing and production; desk top graphics; desk top video; computerized graphics packages; office automation equipment such as electric typewriters; photography; equipment for projection and preparation of projection material; reprography equipment; duplication equipment; audio visual technology involving equipment such as video systems, audio systems and audio-visual recording equipment; techniques for display and exhibition of formatted information, etc. The course will be unstructured in nature and assignments may require study of the principles of the above areas, or the actual use of equipment and techniques.

ENGL G561 Information Technology Lab II 5

(This course is specially designed to prepare the stream of input, viz. traditional English graduates in the use of technology in communication)

This is a sequel to the first course of the same name. The theme of use of modern technology for the purpose of presentation and processing of information for effective communication within an organization would be further developed. However, assignments would invariably emphasize the integration between various technologies for totality of communication.

ENGL G571 Applied Communication I 5

(This course is specially designed to prepare the stream of input, viz. engineering and hard science graduates in communication methods)

Process of communication; elements of speech; role of body language; dyadic communication; participation in different types of discussion groups, audio-visual aids.

ENGL G581 Applied Communication II 5

(This course is specially designed to prepare the stream of input viz. engineering and hard science graduates, in communication methods)

Elements of effective writing; methods of written exposition; art of condensation; writing technical articles, research papers, proposals, reports, manuals and letters, preparation and use of graphic aids; mechanics of writing; technical editing.

ENGL G591 Project Formulation and Preparation 5

This course is designed to inculcate principles of technical documentation as required within S&T organizations. Through this course, students are expected to acquire familiarity with several of the following: Proposals, feasibility reports, formal project reports, short reports, memos, negotiations, contracts, etc. In the process principles of project formulation and evaluation, such as technical considerations; performance specifications; preliminary block diagrams, types and analysis of contracts; cost estimation concepts, work breakdown structure; project data preparation, scheduling facilities etc., would be introduced. The course would invariably include the preparation of a detailed report embodying as many of the above concepts as appropriate.

ENGL G611 Twentieth Century English Literature 5

Margret Atwood, Tony Morrison, Samuel Beckett, Harold Pinter, Philip Larkin, Ted Hughes.

Finance**FIN F212 Fundamentals of Finance and Accounts 3 0 3**

This course is a broad introduction to finance and related areas. An introduction to basic accounting principles for measuring and communicating financial data about a business enterprise to external parties, single and double entry, ledgers, journal, trading, profit and loss and appropriation accounts, trial balance and balance sheet; cash flow statements; capital budgeting and risk management using risk return trade-off notions; introduction to working capital management; structure of capital market; primary and secondary markets; financial market reforms, source of investment information; portfolio selection.

FIN F213 Mathematical and Statistical Methods 3 0 3

Methods of collection and presentation of statistical data; calculation and interpretation of various measures like standard deviation, variance, Kurtosis, correlation coefficient; Sampling Methods - Simple random sampling, with and without replacement, stratified random sampling. Statistic and sample moments, Sampling Distributions - Properties of Student's - t, Chi-square and F-distributions. Theory of Estimation - Point estimation, method of moments; maximum likelihood; interval estimation. Testing of Hypothesis - Statistical hypothesis, simple and composite hypothesis, critical region, types and size of error, test of simple hypothesis versus simple alternative. Analysis of Variance - Analysis of one-way classified data, application in the study of relationships. Theory of Index Numbers - Calculation of Laspeyre's, Paasche's, Fisher's and Chain index numbers, criteria of a good index number, cost of living index numbers, base shifting, splicing and deflating of index numbers. Introduction to Regression Analysis - Specification of simple linear regression model, least square method of estimation, classical assumptions, general and confidence approach to hypothesis testing.

FIN F214 Economic Environment of Business 3 0 3

Business and Economics, Government and business; market and the role of the Government, market failure, Government and the market, government and the firm, Fiscal policy and the environment, Macroeconomic environment; macroeconomic environment of business, Business activity, employment and inflation, monetary policy and economic environment, balance of payment accounting, Business in the international environment; World trade and international monetary system; international investing; investment decisions in multinational markets; country risk; multinational corporate strategy; multinational treasury management; currency risk; globalization and multinational business, FDI, FII, pricing strategy and business.

FIN F242 Introduction to Financial Mathematics 3 0 3

Basic financial calculations; financial securities, time value of money, Annuities and equation of values; discounting and accumulations, flat rate and APRs, Capital Budgeting Techniques and compound interest problems; NPV, IRR, payback period. Arbitrage, Forward contracts, and term structure of interest; rationale of arbitrage assumptions; forward contracts, calculating the forward price, hedging, fixed cash income, spot rate and forward rate, term structure of interest rate, yield curves, yield to maturity, interest rate risk calculation, Stochastic interest models and investments; simple stochastic interest rate models, fixed and varying interest model, log normal distribution, fixed interest government borrowings, government bonds, tax, government bills, convertibles, property, derivatives, future, clearing house, margin, bond futures, short interest futures, stock index futures etc.

FIN F243 Functions and Working of Stock Exchanges 3 0 3

Overview of financial markets and instruments; stock exchanges in India; trading and settlement procedures; listing; risk management; primary markets; debt markets; indices; mutual funds; derivatives; exchange traded funds; corporate governance; SEBI

and regulation of the markets; important events in the stock markets; market microstructure; empirical studies on the Indian markets.

FIN F244 Indian Financial System 3 0 3

Indian Financial System, financial markets, financial intermediaries and financial instruments. Components and structure of the financial system. Financial Assets & Financial Markets: Meaning of financial assets & types, role and structure of money market and capital market – Call money market, Treasury bill market, Commercial bill market including commercial paper and certificate of deposits, Discount market – Government securities market – Debt Market – Industrial Securities Market. Markets for derivatives; futures and options, and other derivatives. Definition and types of non-bank financial institutions, LIC, UTI, Mutual Funds, Venture Capital, bankassurance; their growth and impact on India's economic development. Organisational set up & functions of regulators: Reserve bank of India, SEBI, IRDA, Financial sector reforms.

FIN F266 Study Project 3

These courses include projects which are oriented towards readings from published literature or books about new frontiers of development or analysis of available database. These courses are normally available to students in second or higher levels. These courses must coterminate with project reports.

FIN F311 Derivatives & Risk Management 3 0 3

Overview of Financial Markets. Introduction to derivatives. Definition of future, forward, option and swap. Difference between various players of derivative market, their motives and types of position they can hold. Mechanics of future, option & swap markets. Hedging strategies. Option Pricing and understanding of various factors affecting option price. Calculations of Greeks. Introduction to interest rates, yield, term structure and forward rates. Mechanics of Bond Market. Review of concept of compounding and time value of money. Difference between floating rate and fixed income bonds. Price quotes and accrued interest. Pricing of Bonds. Computation of yield. Bond Price volatility. Duration, Modified Duration and convexity. Factors affecting Bond Yields and the Term Structure. Concept of Risk. Perspective of Risk from view point of individuals, companies & financial institutions. Commercial Banks and risks faced by them. Different types of Insurance and risk faced insurance companies. Introduction to various risks: Market Risk, Credit Risk, Operational Risk, Liquidity risk & Model Risk. Concept of Value at Risk

FIN F312 Fundamental of Taxation & Audit 3 0 3

Legal business entities and tax assessments; profit and gains of business or profession; capital gains; Tax planning for business entities; tax accounting principles; VAT, excise duty, custom duty etc.; computation of tax liability; appeal procedure; auditing procedure and taxation principles; auditing concepts; generally accepted auditing standards; audit documentation and evidence; role of internal N-131 control and concurrent audit; audit mechanism, valuation of assets, and auditing of depreciation, provisions, reserves, profits and dividends, etc.

FIN F313 Security Analysis and Portfolio Management 3 0 3

Introduction to investment and securities; profile of financial assets; new issue market or primary market, initial public offerings (IPO); secondary market; framework of risk & return; fundamental analysis- economy, industry; company analysis; stock evaluation models; multiple holding period and multiple growth rate; bond analysis and bond management strategies; technical analysis; efficient market theory; portfolio management; Markowitz model; Sharpe's Single Index model; capital asset pricing model; financial derivatives-options & futures.

FIN F314 Investment Banking and Financial Services 3 0 3

Merchant banking function- perspectives; organization of merchant banking function; managing new issues; negotiating terms with financial institutions, brokers, investors and under writers; pricing of further issues- SEBI guidelines; syndication of loans from banks; preparation of loan dossiers and application for financial assistance; negotiations; public deposits to finance working

capital; agencies mobilizing public deposits; regulations governing raising of public deposits; cost of public deposits, factoring, forfeiting, structured finance, securitization and personal finance like house loan, personal loan and other individual loans, non-fund based services -credit rating, business advisory services, mergers, de-mergers and acquisition, asset management and insurance commodities services and wealth management.

FIN F315 Financial Management 3 0 3

Concepts and techniques of financial management decision; concepts in valuation - time value of money; valuation of a firm's stock, capital asset pricing model; investment in assets and required returns; risk analysis; financing and dividend policies, capital structure decision; working capital management, management of cash, management of accounts receivable; inventory management, short and intermediate term financing, long term financial tools of financial analysis, financial ratio analysis, funds analysis and financial forecasting, operating and financial leverages.

FIN F341 International Financial Markets and Services 3 0 3

Currency futures, options and swaps; interest rate determination and asset pricing in face of volatile nominal and real exchange rates; international portfolio management; treasury risk management and performance measurement; major international stock exchanges: New York; ISE London; Tokyo; trading and settlement practices; listing of Indian derivatives on Brussels stock exchange; arranging foreign collaboration; floating India funds; syndication of Euro-dollar loans.

FIN F342 Project Finance 3 0 3

Project identification, feasibility; appraisal of projects from technical, financial and economic view points; design of capital structure; factors influencing form of capital; instruments; shares, preference shares, debentures, convertible debentures; borrowing from development finance institutions.

FIN F366 Lab Project 3

FIN F367 Lab Project 3

These courses include projects involving laboratory investigation or laboratory development in the students discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

FIN F414 Financial Risk Analytics and Management 3 0 3

Financial risk (which includes interest rate risk, credit risk, foreign exchange risk and portfolio risk), Application of Asset price Theory, CAPM and Modern Portfolio Theory, Multifactor models of risk and return, Capital adequacy, BASEL Norms; Comprehensive Capital Analysis and Review, Basel Committee on Banking Supervision guidelines, Value at Risk (VaR), VaR from regulator perspective, Responsive VaR Model, Addressing VaR weakness, Backtesting Concepts - Checking the Strength of VaR Model, Issues with the Standard VaR models, Risk Not in VaR (RNIV) to VaR migration of risk, Volatility Clustering, Quantifying and Modeling volatilities, Hedging techniques, Options Greeks, Managing Risk with Derivatives.

FIN F491 Special Project 3

This is an unstructured open-ended course where under the overall supervision of an instructor-in-charge, batches of students will be attached to different instructors. Each batch will work on a specific time-bound project which is of basic or peripheral concern of his discipline. Each student must submit a project report as a culmination of his endeavour and investigation. The instructor-in-charge will determine the choice of the project and also whether or not the project report is to be submitted jointly by a group or individually by a student. The course will aim to evaluate student's actual ability to use the fundamentals of knowledge and to meet new unknown situations as demonstrated by the students' interaction with the instructors and instructor-in-charge and aggregated in the project report. The instructor-in-charge may assign specific hours for formal brain-storming sessions.

French

FRE N101T Beginning French 3

Basic grammar; vocabulary; reading practice; translation of simple passages.

Not available for meeting the requirements of any programme except as prerequisite for another French course. Can be taken only on audit.

FRE N102T Technical French 3 0 3

Prerequisite : FRE N101T

Phrases and sentence patterns in technical literature; special technical vocabulary; reading and translation of current technical literature from French to English with the help of a dictionary.

This course is designed to meet the foreign language requirement of the Ph.D. Programme and is not available for meeting the requirement of any other programme. Can be taken only on audit.

German

GER N101T Beginning German 3 0 3

Basic grammar; vocabulary; reading practice; translation of simple passages.

Not available for meeting the requirements of any programme except as prerequisite for another German course. Can be taken only on audit.

GER N102T Technical German 3 0 3

Prerequisite : GER N101T

Phrases and sentence patterns in technical literature; special technical vocabulary; reading and translation of current technical literature from German to English with the help of a dictionary.

This course is designed to meet the foreign language requirements of the Ph.D. programme and is not available for meeting the requirements of any other programme. Can be taken only on audit.

General Studies

GS F211 Modern Political Concepts 3 0 3

Nature and scope of political science; emergence and basis of the state; rights and duties; forms of government; democracy, fascism, capitalism, socialism, anarchism, communism, Maoism, radicalism and Gandhism.

GS F212 Environment, Development & Climate Change 3 0 3

Specific topics on environment, development and climate change; regional, national and international climate debates; review of international climate negotiations such as Kyoto, Copenhagen and other declarations; environment problems: causes, sustainability and policies; population, resources and sustainability; population dynamics, capacity and conservation; food security, poverty, impact and global solutions; energy resources: renewable, wind, oil, natural gas, nuclear energy; growth, technology and greenhouse gas emissions, carbon credit; regional impacts of climate change and adaptation strategies; techniques in modeling; water resources and pollution: monsoon, drought, rainwater harvesting, traditional practices in water conservation; case studies.

GS F213 Development Theories 3 0 3

Course description is to be developed.

GS F221 Business Communication 3 0 3

Managerial communication – national and international contexts, Interpersonal Communication, persuasive communication, communication technology, effective listening group communication, professional presentation.

GS F222 Language Lab Practice

0 3 3

Writing: Grammar and usage, sentence completion, jumbled sentences, emphatic word order, vocabulary building, message organization, paragraph development techniques and note taking. Reading: Skimming, scanning, rapid reading, analytical reading, factual reading, and aesthetic reading. Listening: Content listening, critical listening, aesthetic listening, empathetic listening, listening to short conversations, stories, lectures.

GS F223 Introduction to Mass Communication 3 0 3

Mass communication: an overview, history of media and media plan, cinema, radio, television, theatre, advertising, audience and media, public relations, writing for media, new information technology: software revolution, internet, social media, video conferencing.

GS F224 Print and Audio-Visual Advertising 3 0 3

The Dimensions of Advertising; Advertising and Marketing; Creative strategy and Creative process; Creative Execution: Art and copy; Media strategy; Advertising research; Relationship Building: Public relation and Corporate advertising; Ethical issues.

GS F231 Dynamics of Social Change 3 0 3

Nature of society, social institutions; concept and nature of socio-cultural change, obstacles, rate and direction of change; factors of social change-ideological, economic, technological and political demographics; agencies of social change-education, leadership, propaganda, legislative reforms; five-year plans and social change, peasant and land reform, bhodan and gramdan; changing pattern of family, marriage, caste and religion.

GS F232 Introductory Psychology 3 0 3

The development of psychology as a science -- individual and the environment; nature; kinds and determinants of perceptions; response mechanism and kinds of responses, motivations, modifications of behaviour through learning, memory and transfer of training; thought processes, problem solving and creative thinking; nature and characteristics of psychological tests; nature and evaluation techniques of intelligence and personality.

GS F233 Public Policy 3 0 3

Public Policy-meaning nature and types; approaches and models of public policy; nature of public process-process in the executive; parliamentary processes; processes to manage the ruling party-government interfaces; strategic thinking on the process of policymaking, judicial policy making.

GS F234 Development Economics 3 0 3

Concept of development; statistical foundation of decisions; nutrition, disease and climate as influences on growth; critical importance of population; importance of agriculture, international trade and industry; cost-benefit analysis and planning process.

GS F241 Creative Writing 2 1 3

Principles of creative writing; stimulating creative activity; techniques of creating images; constructing events and creating characters, writing short stories, plays and poems, writing critical essays on works of art.

The course will require from the student a comprehensive report on the techniques learnt and include samples of his creative writings.

GS F242 Cultural Studies 3 0 3

Introduction to Cultural studies, Importance of cultural studies, types of cultural studies, relation to Critical theory, relation to Literary Criticism. Introduction to theories such as Communication studies, Film studies, Feminist theory, Art history/Criticism, Societal impact, business relevance, introduction to myriad practices, institutions, beliefs and varied social structures within a given culture.

GS F243 Current Affairs 3 0 3

Introduction, importance and scope; domains: political, social, religious, scientific, developmental, etc.; categories: controversial,

non controversial, neutral; sources of information: newspapers, magazines, posters, pamphlets, manifestoes, etc.; reading skills: skimming, scanning, extensive and intensive reading; understanding, interpreting and analysing news, events and information; forming, balancing and expressing opinion.

GS F244 Reporting and Writing for Media 3 0 3

Reporters and their functions; What makes news; Analysing the components; Getting the information and putting it together; Organizing a news story; Building colour into news stories; Fighting the formula story; Writing Leads; Message molecules (Vocabulary, grammar, Spelling), Human Interest and Depth Report; Finding and using news sources; Basics of ethics in Journalism.

GS F245 Effective Public Speaking 2 1 3

Principles of public speaking; importance of effective listening; use of body language; characteristics of voice; ways to control stage fright; measures to develop confidence; audience analysis; modes of delivery; organization of speech; speeches for special occasion: welcome, introduction, felicitation, farewell, valedictory, inaugural; impromptu and extemporaneous speeches; meetings, group discussions, professional presentations, interviews.

(This course is extensively practice-oriented. Theoretical guidelines also will be given to the students for achieving effectiveness in public speaking. Students would be asked to prepare and deliver a number of talks and presentations. Comments and discussions will follow each presentation so as to provide the students opportunity to correct themselves. Group discussions and presentations will be recorded and projected for them to observe their organization, body language and understand the nuances of the characteristics of their voice. Evaluation components will be designed to assess the students' ability to listen actively and speak effectively. The new language laboratory will be used to enable the students to listen to speeches by eminent leaders and renowned personalities who were/are able to attract the masses with their powerful speeches. The lab would also be used to conduct group discussions through computers).

GS F266 Study Project 3

These courses include projects which are oriented towards readings from published literature or books about new frontiers of development or analysis of available database. These courses are normally available to students in second or higher levels. These courses must coterminate with project reports.

GS F311 Introduction to Conflict Management 3 0 3

Characteristics and dynamics of conflict, reasons for conflict; the value of conflict in social change; the different approaches to addressing and managing conflict; Examining the history and impacts of a conflict; exploring stakeholder power and relationship; assessment of options to address conflict; tools for determining the best strategy; incentive and methods in getting stakeholders to collaborate; active listening; skills in mediation and facilitation; roles of mediator and facilitator in conflict management; dealing with emotions and difficult situations; planning and preparing for negotiations; improving negotiation skills; joint problem solving approaches; building agreements; building conflict management mechanisms and consensus-building strategies.

GS F312 Applied Philosophy 3 0 3

Content of Philosophical Perspectives – Ethical, Logical, Epistemological and Metaphysical; Ethics and Social Dilemmas; Social Justice and Equality; Freedom of Expression; Social and Value Dimensions of Technology; Impact of Information Technology on the Quality of Life; Computer and Internet Crime; Democratic Values and the Internet.

GS F313 Marxian Thoughts 3 0 3

Marx and his times; basic tenets; dialectical materialism; economic determinism; doctrine of surplus value; doctrine of class struggle; different schools of Marxism; Leninism; Stalinism; Maoism; future of Marxism.

GS F321 Mass Media Content & Design 3 0 3

Types of Corporate Communication documents; Importance of corporate communication; communication documents for stakeholders; Data collection for documents- Sources, types, methods; Analyzing and Organizing the content – preparing the drafts; Design Concepts; Design Technologies – Overview; Specific Design tools – Dreamweaver, Macromedia Director, Adobe Premier, Photoshop, Flash; Integrating Content and Design.

GS F322 Critical Analysis of Literature and Cinema 3 0 3

Creativity and Aesthetics; An overview of Major Movements in Literature and Cinema; Interpretation of Selected Works; Cinema & Art; Understanding Drama: Theme, Character, Plot, form; Understanding Poetry: Diction, Imagery, Symbolism, Structure and Form, Personification, Apostrophe, Sound and Rhythm; Understanding fiction: Setting, Point of View, Plot and Character; Understanding Short Fiction: Meaning and message, Style and Coherence; Understanding Cinema: Plot; Character; Screenplay; Linguistic, Social, Musical codes; Cinematic Codes; Camera Work.

GS F325 Journalism 3 0 3

Principles of reporting; the news media and public relations; ground rules for reporters; investigative reporting; specialised reporting of events, trends and activities; creating headlines; editing, copyediting; newspaper style; proof reading; the press and the law.

GS F326 Creative Thinking 2 1 3

Creative thinking & its importance, Process of creative thinking, Road blocks to creative thinking, Developing creative thinking, Brainstorming, Bloom's Taxonomy, Assessment of creative thinking, Conceptual framework for Critical thinking, Aspects of critical thinking, Stages of critical thinking; Reasoning: Fountain head of critical thinking, Need & benefit of critical thinking, Critical thinking in decision making, Developing critical thinking in classroom, Assessment of critical thinking skills.

GS F327 Selected Reading 3 0 3

The course is intended to nurture the students' critical thinking and to enhance their skills at information gathering and expressing. Selected readings from books in the areas of History, Science & Technology, Culture, Literature, Art, Philosophy, Psychology, Religion, Development Concepts and Trends etc. will be assigned to the students. A set of books will be identified in at least two broad areas for study and analysis. This course is designed only for students of M.Sc.(Tech.) General Studies Programme.

GS F331 Techniques in Social Research 3 0 3

Principles of social research, research process, stages of social research, choosing the research problem, objectivity and subjectivity in social research, ethics in social research, ethical codes of practice, confidentiality and anonymity, privacy, Effects of Value in social research, constructing social explanations, descriptive studies, explanatory studies, designing a social research proposal, quantitative research, survey, sampling, SPSS, various statistical tests, qualitative research, observation: participant and non-participant, issues in conducting qualitative research studies, case studies of socio-economic, political, health, gender and developmental issues, interview as social interaction, ethnographic research, field study, hypothesis testing, analysis of data, report preparation and documentation, factors limiting application of social research, evaluation research and development of social indicators.

GS F332 Contemporary India 3 0 3

Topics will include some or all of the following: economic process; contemporary Indian planning and industry; political processes; Contemporary Indian political scene and Indian administration: India and the contemporary world; social processes: contemporary Indian educational scene; religion and caste system; Indian science; Indian women; cultural processes; contemporary Indian art, music, dance, theatre, cinema and literature.

GS F333 Public Administration 3 0 3

Definition, nature and scope of public administration; the chief executive; leadership qualities of an administrator; principles of organization; organization of Ministries of Home and Finance; personnel administration-bureaucracy; recruitment, promotion, conduct and discipline, employer-employee relations; administration at work-planning, policy formulation, decision making, supervision, coordination; integrity in administration; public corporations in India; financial administration in India; local administration in India.

GS F334 Global Business, Technology and Knowledge 3 0 3 Sharing

Changing corporate landscape, New knowledge industries, networking and interdependence, Technology: a fundamental driving force, WTO. Global Business Environment, Intellectual Property Rights (IPR), FDI, trends in India and comparison with China. Technology import and export, Technology transfer and adaptation. Need for technology intermediation, newly emerging technology-business opportunities, technology forecasting, technology assessment, technical actions. The role of small and medium enterprise's and the changing roles of enterprises. Leadership for the inter-networked business, Employment and Jobs, access and equity, quality of life, global knowledge innovation infrastructure.

GS F342 Computer Mediated Communication 3 0 3

Course description is to be developed.

GS F343 Short Film and Video Production 2 1 3

Introduction; communication media formats like audio, film, video, audio recording and editing; image composting; script writing : screenplay; equipment: video cameras, film cameras, the lens, the camera; the film stock: negatives, prints, aspect ratio, grain, gauge, speed, colour contrast, tone; handling the camera; image technology, sound technology; basic filming techniques: lights and lighting, shooting, sound recording, sound track, dubbing, voice over; visual effects, editing: familiarization with editing software, mixing and looping; final production.

GS F344 Copywriting 2 0 2

Concept of Copywriter, Setting up as a Copywriter, Copywriting Audience, Copy Writing Process, Marriage of Visual and Copy, Copy Types-Email Marketing, Direct Mail Press Release, Press Ads, Writing Leaflets and Brochures, Newsworthy Newsletters, Radio Copy, Online Copywriting, Other Types of Copy.

GS F345 Constitution of India 3 0 3

Practical, historical and legal importance of the constitution of India; evolution and features of the Constitution of India; India's political, social, and economic processes as envisaged in the Constitution; implications for democracy; institutions, aspirations, philosophy, and nature of the constitution; democratic logic of the Indian State; relationship between the individual and the State.

GS F366 Lab Project 3**GS F367 Lab Project 3**

These courses include projects involving laboratory investigation or laboratory development in the students discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

GS F491 Special Project 3

This is an unstructured open-ended course where under the overall supervision of an instructor-in-charge, batches of students will be attached to different instructors. Each batch will work on a specific time-bound project which is of basic or peripheral concern of his discipline. Each student must submit a project report as a culmination of his endeavour and investigation. The instructor-in-charge will determine the choice of the project and also whether or not the project report is to be submitted jointly by a group or individually by a student. The course will aim to evaluate student's actual ability to use the fundamentals of knowledge and to meet new unknown situations as demonstrated by the students' inter-

action with the instructors and instructor-in-charge and aggregated in the project report. The instructor-in-charge may assign specific hours for formal brain-storming sessions.

Humanities and Social Sciences**HSS F211 Introduction to Arabic 3 0 3**

Recognition of Arabic alphabets; Understanding and practice of Arabic grammar; Comprehending paragraphs and reproducing it in simple Arabic; Reading and interpreting short Arabic stories, newspaper headlines; Listening and understanding radio and TV news; Vocabulary building; Using profession specific words and phrases related to engineering and business; Conversation with Arabic speaking people in different situations such as introduction and greetings, interaction with family and friends, communication during vacation and holidays, communication at the workplace, restaurant, bank, government offices, asking and answering questions during job interviews, attending phone calls, etc. (emphasis will be on Standard Arabic and Emirati dialect).

HSS F221 Readings from Drama 3 0 3

Oliver Goldsmith, John Galsworthy, T.S. Eliot, John Osborne.

HSS F222 Linguistics 3 0 3

Linguistics as a field of study and its relationship with other disciplines; nature of language; its varieties and role in society; concepts of structure, system, unit and class; theories of linguistic analysis.

HSS F223 Appreciation of Indian Music 3 0 3

The course is intended as an appreciation of Indian music; the emphasis will be upon exposing the students to musical performances, records, tapes, both vocal and instrumental; through these illustrations the consciousness in terms of the distinction between Raag and Taal etc., is expected to be derived; the course will pick up a certain number of Raags from the basic thaats and demonstrate the delineation of the Raag through Alap, through various improvisations based upon compositions; the appreciation of concepts both vocal and instrumental (Sitar and Violin) is expected to be obtained; Karnatik music will also be touched upon particularly in terms of Raags common to Hindustani Music.

HSS F224 English Skills for Academics 3 0 3

Nature and scope of English for specific academic purposes; Common core academic genres: description, narration, cause-effect, problem solution, and argumentative; Writing for specific purposes: paragraphs, essays, critiques, research; Academic English lexis: AWL and AVL; Lexical cohesion: adverbials, collocations; Publication of word lists for English for specific purposes: corpus-based study (through AntConc tools); Discourse patterns: argument & counter argument, self-referencing, adverbials; Language use: DIY activities for word, phrase, clause and text level aspects of discipline specific texts

HSS F226 Postmodernism 3 0 3

Postmodernism, The Postmodern Condition, History of Postmodernism in brief, Pluralism, Eclecticism, Polysemy, Intertextuality, Metanarratives, Language Games, Parody, Pastiche, Simulation, Postcolonialism, Commodification, Deconstruction and New Historicism, Creativity, Critical Judgment, Ethical and Social Understanding, analysis of postmodern cultural artifacts and practices from fine art, music, theology, literature, and film alongside primary texts by the leading theorists of postmodernism.

HSS F227 Cross Cultural Skills 3 0 3

Overview of Intercultural Communication, Intercultural Communication in the Global Workplace, Technology as cultural Power and Its Social Impact, Critical Issues and challenges in Intercultural Communication, Understanding interrelatedness among Religion, Family, Culture, Gender and Race.

HSS F228 Phonetics and Spoken English 3 0 3

Speech mechanism; the English phonemes; word accent; features of connected speech; phonetic transcriptions; varieties of spoken English; spoken English in India; problems of Indian

speakers; oral reading of passages including conversation; speech training.

HSS F229 Introduction to Western Music 3 0 3

A historical and cultural examination of music in Western culture from the Middle Ages to the 21st century; Listening to and understanding different genres of music; Fundamentals of Music: Rhythm, Meter and Measure; Melody and Harmony; Pitch names; Intervals; Key signatures; Chord progressions; Score reading; Intune singing; Ear training; Making music on the electronic keyboard.

HSS F232 Introduction to Development Studies 3 0 3

History of development; meanings of development; Key development thinkers: Smith, Marx, Liszt, Keynes, Prebisch, Friedman; 20th century perspectives on development: dependency, modernization, human development, post- and anti-development theories; Models of development: ISI and neoliberalism; Themes in comparative international development: environment, health, gender, foreign aid, social and human rights.

HSS F233 Main Trends in Indian History 3 0 3

A panoramic view of the development of Indian thought and society; evaluation of Indian life and quality from earliest times through the so-called Hindu, Muslim and British periods; the present day analysis and discussion on the basic features of Indian society, its strength and its weakness; a glimpse into future in terms of the transformation of the Indian society.

HSS F234 Main Currents of Modern History 3 0 3

Renaissance, the major revolutions of the world; rise of nationalism; growth of imperialism; world between the two world wars; super powers and the contemporary world; resurgence of Asia, protest movements in Africa and Latin America; problem of world peace.

HSS F235 Introductory Philosophy 3 0 3

An overview of some philosophical theories and issues both from India and the western world; nature and purpose of philosophy; theories of cosmology, metaphysics and epistemology; skepticism and its philosophical value; contemporary philosophy.

HSS F236 Symbolic Logic 3 0 3

A brief historical survey of the development of logic; nature and kinds of arguments; sentential connectives; symbolization of statements and arguments; truth tables, establishing validity of arguments by truth tables and different types of proofs, quantified statements; quantified arguments and their validity.

HSS F237 Contemporary Indian English Fiction 3 0 3

Indian novel in English as a global phenomenon; pioneering publications; new approaches to the art of storytelling and reworking of language introduced in Indian English fiction. Developments in contemporary Indian fiction in English from the 2000 to the present; Analysis of selected novels set in their historical, political, social and cultural contexts, and alternate view-points on contemporary India.

HSS F238 Sports and Society 3 0 3

The Sociology of Sport; Theories; Sports and Socialization; Sports and Culture; Deviance and Violence; Class, Gender, Race and Ethnicity; Sports and Education; Sports and Economy; Sports and Politics; Sports and Media; Sports and Globalization.

HSS F242 Introduction to Phonology 3 0 3

Means of communication; language differences; human speech sounds; organization and structure; deployment; historical evolution; tools and theoretical framework; formal analysis of data; theories.

HSS F243 Introduction to Critical Pedagogy 3 0 3

Critical pedagogy; ideology and education; oppressive vs. liberatory pedagogy; practice of freedom; democratic education; hidden curriculum; power in classroom; politics in classroom; class; religion; gender; sexuality; disability; examination and impact; mind as

blank slate; awakening critical consciousness; humanistic teaching.

HSS F244 Crime and New Media 3 0 3

Biological Theories: The 'Born Criminal', Social Darwinism, Detective Fiction and the Forensic Method, Monstrous Bodies; Psychoanalytic Theories: Trauma and Perversion, Trigger Warning, Voyeurism, Spectacle of Punishment; Social Disorganization Theories: Sociopath and Vigilante, Organized Crime, Cyber Bullying and Trolling, Panopticism; Feminist Theories: Female Offender, Female Victim, Law Enforcement, Social Rights Movements.

HSS F245 Gender, Science and Technology 3 0 3

Introduction to science studies: Nature of science and technology, Modern Western science, Science study debates in Indian sub-continent; Gender, science and technology: Sex and gender, Representation of genders in science and technology, Access and retention; Feminism and science: Practice of science and gender, Feminist epistemology; Feminism and technology: Gender-technology debates, case studies.

HSS F246 Philosophy of Nāgārjuna 3 0 3

Abhidharma notions; Rejection of aggregates, elements, and conditioned entity; Desire and the desirous, agent and action, and fire and fuel; Ontological independence, prior entity, initial and final limits, intrinsic nature, and compounded phenomena; Early-Buddhist views on suffering, bondage and freedom; Action and consequence; Self and entities within substance metaphysics; Time, origin and dissolution of existents, Tathāgata, assemblage, and conjunction; Four noble truths, nirvāṇa, and the twelve links of dependent origination.

HSS F247 Social Informatics 3 0 3

Intro to Social Informatics; Evolution of Social Informatics-India and Global; Right to Information and Consent of the Networked; Critical Informatics; Infrastructure and Equitable Information Technology; Identity and Community; Hackers and Hacking; Ethics, Law, and Policy related to ICT; Big Data; Privacy and Surveillance; Artificial Intelligence and impact on Social structure, Commercialization of Social Informatics.

HSS F248 Introduction to Disability Studies 3 0 3

Critical interdisciplinary field: socio-cultural and historico-political perspectives of disability. Historical construction of able-bodiedness, normalcy, disability, abnormality. Disability-centred critique of medical technologies and psychiatric practices. Culturally different ways of knowing body-minds. Disability in relation to other bio-social differences like gender, caste, class, race and sexuality. Disability expressions: life writing, autism narratives, sign-language poetry, crip performances.

HSS F249 Politics in India 3 0 3

Institutional Setting of the State; Transformed structures of political power; Constitutionalism; Parliament; The Party System; Social Cleavages; Identity, Class, Caste and Religion in Politics; Politics and National Identity; Political Processes; Political Parties; Social Justice; Social Movements; Politics and Redistribution

HSS F250 Comics and Visual Culture 3 0 3

A historical and cultural examination of popular visual culture; case studies from comic books, manga, graphic novels, memes, and caricatures; transnational approach spanning India, Japan, and America; visual methodologies; critical theory on culture industry, political satire, patriarchy, and public morality; intersections of class, caste, gender, and racial violence in visual media.

HSS F251 Introduction to Discourse and Conversational Analysis 2 1 3

History and background of discourse analysis; relationship of discourse and society; patterns in text organization; genres and text types; stance of writers; patterns in talk and conversations; stance of speakers; databases and corpora; methodologies and tools for conversation analysis.

HSS F252 International Law**3 0 3**

services; Theories of International Law: Realism, idealism, and other schools; Process of making of international laws; Role of international institutions in the making of international law; Law of treaties, ratification, reservation and withdrawal process; International courts and tribunals; State and international law, recognition of states, statehood, sovereignty; Evolution of law of the seas and air space; High seas as global commons; Law related to freedom of navigation on high seas and airspace; Digital sovereignty and international cyber laws, data theft and breach of privacy; International environmental law; International climate change treaty; Law to protect biosphere; Legal aspects of international sanctions; Rule of law in international politics: Use and abuse.

HSS F253 Upcycling Theory**3 0 3**

Introduction to Post-Structuralist Theory; Deconstructive Principles and their Application in Upcycling; Rethinking Material Culture and Significance in Upcycling; Exploring Fragmentation in Upcycled Creations; Embracing Multiplicity in Upcycled Designs; Upcycling Methods and Techniques; Applying Post-Structuralist Principles to Upcycling Practice; Exploring Eco-Aesthetics in Upcycled Artworks; Community Involvement and Collaboration in Upcycling Projects; Examining Jugaad as a Form of Upcycling and Innovation; Integrating Sustainability into Upcycling Practices; Cultural Perspectives on Upcycling Practices; Creating Upcycled Artworks; Exploring Perspectives Beyond Traditional Academia in Upcycling; Upcycling as a Component of Circular Economy Practices; Implementing Sustainable Design Principles in Upcycling Projects, and Upcycling as a Catalyst for Social and Environmental Change.

HSS F266 Study Project**3**

These courses include projects which are oriented towards readings from published literature or books about new frontiers of development or analysis of available database. These courses are normally available to students in second or higher levels. These courses must coterminate with project reports.

HSS F311 Introduction to Videogame Studies**3 0 3**

Introduction to videogames- a brief history of videogames, game studies as a multidisciplinary academic field, play and game- deconstructing videogames: narrative structures of videogames, critiquing rules in videogames, immersion and materiality- puzzles, drama and socio-technical system of video games- Themes of videogames: violence, addiction, language, sexuality, gender, identity, communities, values and ethics- game genres: e-sports, indie games, serious games- gamification, game design; developing story, action and characters in videogames- Game market and economics, game journalism.

HSS F312 Bureaucracy**3 0 3**

Course description is to be developed.

HSS F313 Introduction to Contemporary Arts**3 0 3**

Methodologies of viewing contemporary art and its cultural, political, Philosophical and environmental underpinnings- the basic principles of Western and Eastern art - Indian art history at a glance - different mediums of artistic practice through the ages - modern art- connecting art and technology.

HSS F314 Maritime Studies and Blue Economy**3 0 3**

A comprehensive idea on the growth of maritime history, evolution of maritime economies, conventional and evolving strategic concerns, responses and naval diplomacy- Maritime communities: structures, changes and influences Evolution, Growth & Development of Maritime Transportation -Maritime Mobility- Growth of Ancillary Sector- Maritime Issues & India International Port & Shipping Economy- National, Regional & International Maritime Security Paradigms- Maritime Governance

HSS F315 Society, Business and Politics**3 0 3**

Course description is to be developed.

HSS F316 Popular Literature and Culture of South Asia**3 0 3**

South Asia as a region; culture and its representation through literature and cinema; politics of representation, breaking the stereotypes; bringing in the marginalized voices; writings of women; identity formation; concept of majority and minority; commonality in spite of all the differences, violence, migration and dislocation.

HSS F317 Introduction to Globalization**3 0 3**

Main themes and concepts: Globalization, Globalism, Localization, Glocalization; Dimensions of Globalization: Social, cultural, economic, political and ideological; Processes related to Globalization: Internationalization, Westernization, Americanization, Neo- Colonialization; Relationship with issues of environment, city, consumption, media, inequality; Development; Impact and consequences of Globalization in India; Challenges and future of Globalization: Anti-Americanization and Anti-Globalization Movements.

HSS F318 Introduction to Anthropology**3 0 3**

Introduction to Social and Biological Anthropology: Human Nature, Race, Evolution; Sex, Gender, Family; Archaeology: Domestication, Agriculture, and Civilization; Cultural Anthropology: Nature of Culture, and Cultural Relativism; Nature of Language and Languages.

HSS F319 Lighting for Theatre and Films**2***

Design principles and elements of design; lighting instruments; lighting mechanics, rigging and focusing lights; color and color theory, psychology of color, color mixing; lighting paper works, lighting for play, opera, thrust, musical, proscenium, arena and films.

HSS F323 Organizational Psychology**3 0 3**

Industrial/Organizational Psychology, Hawthorne Studies, Leadership-Theories, Motivation-Concepts, Personality & Values: Strengths & Weaknesses, Employee Issues: Recruitment, Training & Development, Organizational Change & Development- Psychosocial Aspects, Organizational Culture & Climate, Work-Family Balance, Stress and its Management, Positive Organizational Psychology.

HSS F325 Cinematic Adaptation**3 0 3**

Essentials of literature; types and characteristics of literary writings: story and plot, character, theme, setting, point of view, incidents, characters, and dialogues; film history, types of adaptations; features of adaptations; importance of adaptations; trend of adaptations; process of adaptation; cinematic text; essentials of cinema: dialogues, text, screenplay, etc.; critical analysis of adaptations; current trends and challenges.

HSS F326 Humanities and Design**2 2 3**

Ideas and Designs, Thinking about New Designs, Perspectives to Design: Historical, Social, Technical and Creative Dimensions; Engineering Design and Problem Solving; Basic Concepts in Engineering Design; Design Skills, Abstraction, Identification of Patterns in Processes and Products, Application of Systematic Techniques to Problem Solving, Application and Adaptation of tools and technologies to new problems; Core Principles of Design; Elements of Design, Form and Functionality, Central Activity of Engineering Designs; Language and Interface Design, Design Thinking: Influence of Context Vs. Conflict with Context.

HSS F327 Contemporary Drama**3 0 3**

Course description is to be developed.

HSS F328 Human Resource Development**3 0 3**

The strategic role of human resources management; human resource development – concept, goal, mechanism, and design the system; manpower planning and policies; staffing process- recruitment & placement, job analysis, selection, managing employee separation, downsizing and outplacement; maintaining & developing people- training & development, developing managers, appraising performance, managing career, employee remuneration.

neration; governance- developing employee relations & communication, respective employee rights & managing discipline; trade union; managing safety & health.

HSS F329 Musicology – An Introduction 3 0 3

Music and its philosophy, history of music, different theories regarding the development of music, music as an exact science (mathematics), musical terminology, musical forms and their background, composers, artistes and their contributions, music of different cultures, music and film world, music therapy. Emphasis would be laid on research and knowledge gained through self-experience.

HSS F330 Appreciation of Art 3 0 3

Visual perception and basic techniques used in art, compositional balance, space, movement form, light colour, texture, tensions, expressions lines; mainstreams of art; influence of Indian art abroad; various schools of art-Greecian, Medieval, Christian Renaissance, Baroque and Romanticism, impressionism and post impressionism, fauvism, futurism, expressionism, Dadaism and surrealism, metaphysical art, non-representational and abstract art; analysis of work of art and their evaluation.

HSS F331 Sankara's Thoughts 3 0 3

Life and achievements of Adi Sankara; pre-Sankara Vedanta; basic concepts and theories of Advaita: Atman and Jeeva, nature, sources and validity of knowledge, Brahman and Isvara, Maya and World, Avidya, bondage and liberation; Sankara's contribution to Indian heritage.

HSS F332 Cinematic Art 3

Cinema as an art form; elements of cinema; defining form, style types, rhyme as adopted in global cinema; new idiom in Indian cinema; experimental techniques; evolution of the language of cinema; analysis of Japanese, Swedish, American, French and Indian cinema; theatre and cinema.

HSS F333 Comparative Religion 3 0 3

A clear objective description of the great religions and their appeal to the spiritual aspirations of the different people of the world; a comparative non-sectarian approach to the understanding of Hinduism, Buddhism, Islam and Christianity; a final summing up bringing the unity of all religions of the world.

HSS F334 Srimad Bhagavad Gita 3 0 3

The science of Soul; Reincarnation; Karma; Karma Yoga; Transcendental Knowledge; Action in Krishna consciousness; Dhyana Yoga; Knowledge of the Absolute; Attaining the Supreme; The process of Transmigration; the most confidential knowledge; Bhakti Yoga – The process to go back home, back to Godhead.

HSS F335 Literary Criticism 3 0 3

Aristotle, Dryden, Johnson, Coleridge, Arnold, Eliot.

HSS F336 Modern Fiction 3 0 3

E.M. Forster, Virginia Woolf, Joseph Conrad, Aldous Huxley, D.H. Lawrence.

HSS F337 English Literary Forms and Movements 3 0 3

This course is designed to provide a historical perspective on major forms and movements in English Literature and to develop an insight into various social, religious and other influences on their birth and growth. The course will cover the entire range of literature from renaissance and reformation to modern times.

HSS F338 Comparative Indian Literature 3 0 3

This course is intended to acquaint the students with literary achievements in Indian Languages and their home-environment and to give integrated view of Indian literature, literary selections from the best writers in the Indian languages will be studied.

HSS F339 Theatre Art-Acting and Production 3 0 3

General historical background of theatre; general knowledge of acting; its tools and exercises; voice training and practice; a study

of stage; various systems of theatres; rehearsal techniques and stage management.

HSS F340 Post Colonial Literature 3 0 3

Introduction to Post colonial discourses; Post Colonial Concepts: Colonization, De-colonization, Linguistic colonization, Politics of representation, Orientalism, Euro-centrism, Hybridization, Select Literary Texts.

HSS F341 Performance Design 3 0 3

Study of a dramatic text and its genre, structure; plot, time, theme and its development, character; music and spectacles; conceiving scenography: basic principles of design; reading the hidden image in the text; performance and show; organizing performing space, conceiving light, music, and sound; staging the show: final production.

HSS F342 Advanced Communicative English 3 0 3

Pronunciation, Accent, Intonation, Vocabulary, Active Listening, Conversation, Group Discussion, Dynamics of Writing, Art of condensation, Dictogloss, Critical Essays, Academic Essays, Term Paper, Book Review.

HSS F343 Professional Ethics 3 0 3

Ethics, nature and purpose; ethical theories; ethics in business and management; ethics in engineering, global ethical issues.

HSS F344 Heritage of India 3 0 3

Foundations of India; India and her ancient culture; life of the people; systems of Indian philosophy; art and archaeology; languages and literature; impact on world civilization; Western influence.

HSS F345 Gandhian Thoughts 3 0 3

Sources of Gandhian thoughts, metaphysical convictions, ethical principles, ends and means; Gandhi and religion; theory of satyagraha; political thought; economic thought; social reforms; untouchability; Gandhi and Muslims; Gandhi and women; some items of constructive programme, Gandhi and Marx; his nonviolent state; Gandhism after Gandhi.

HSS F346 International Relations 3 0 3

Rise of nationalism, World War I, Interregnum; World War II and after; bi-polar politics and detente; instruments for promotion of national interest; diplomacy; propaganda and political warfare; integration of Western Europe; West Asia and world politics; panchsheel and nonalignment; major national foreign policies--USA, USSR, UK and Pakistan; disarmament; UN and World peace.

HSS F347 Introduction to Carnatic Music 3 0 3

Origins and History of Carnatic music; Basic concepts of svara, svaravalis, svarasthanas, aarohana, avarohana, sthayis; Concept of laya, tala, gati, nadai, different jaati's of taalams; Concept of raaga, Melakarta andjanya; Ragalakshanam for some specific raagas; Notation of svaras, taalam; Brief biography of the Trinity, Purandaradasa, and other major composers; Concert formats and styles; Vocal or instrumental exercises including varisais, Sap-tataala alankaaras, Geetams, svarajati, keertanams; Listening practice.

HSS F348 Introduction to Hindustani Music 3 0 3

Origins of Hindustani music and evolution of the style; Basic concepts of melody and rhythm: Naad, Dhvani, Sangeet, Swar, Laya, Raag, Taal, Shuddh- Vikrit, Chal-Achal, Mandra-Madhy-Taar, Poorvang – Uttarang, Saptak - Ashtak, Sthayee – Antara, Aroha-Avaroha, Raag-Jati, Tal Jati, Alap-Tan, Varn, Alankar, Pakad, Bandish, Vilambit-Madhy-Drut, Matra, Theka, Vibhag, Tali, Khali, Sam. Raaga, Thaata, raag vivara; Compositions: khayals, dhrupad, taraana etc; Vocal or instrumental exercises including ten alankars, Identification of svaras, Aroh, avaroh and pakad of simple raags viz. Yaman, Bhoop, Khamaj, Des, Kafi, Bhimpalasi, Bageshri, Durga; Sargam geets, lakshan geets and madhyalay khayals; Taals including Trital, kaharva, daadra; Listening, identification of raaga from simple phrases.

HSS F349 Ecocriticism**3 0 3**

Defining Ecocriticism; Interdisciplinarity; Ecosystem and Biodiversity; Ecology and Environment; Developmental Ecology; Ecocritical Concepts; Literary Ecocriticism; Application of Ecocritical Principles in Literature - tinaí Criticism; Deep Ecology; Bioregionalism - Cultural Ecocriticism; Ecocinema - Debates on Anthropocentrism and Biocentrism/Ecocentrism; Food documentaries; Animal Studies; Ecophobia; Gaia Theory; Ecocriticism and Society; Ecopolitics and Activism; Ecospirituality and Ecosophy; Practical Ecocriticism.

HSS F350 Human Rights: History, Theory & Practice**3 0 3**

The meaning and history of human rights; Human rights debates and controversies; Political, civil, social and economic rights; Culture and human rights; Themes - Democracy, dictatorship, and human rights; Science, technology, and human rights; Ethnicity; Gender; Children's rights and others; Evaluating the progress made and challenges in practice of human rights.

HSS F351 Social and Political Ecology**3 0 3**

Environmental History and Social construction of nature; Theoretical perspectives on Natural Resource use; Ecological Development; Natural Resource Governance; Ecological Identity and Social Movement-Gender-based dimensions; Degradation and Marginalization; Conservation and Control; Ecotourism; Urban Ecology; Regional case studies.

HSS F352 Technology, Work and Society**3 0 3**

Work during and after Industrial Revolution; Major theoretical contributions to the study of Work; Technology and its impact on work in the 21st century; Work and self in the service industry; Work and self among professionals and managers; Changes in Culture of Work; Domestic labor and the politics of household work; Modern distinction between work and family.

HSS F353 Philosophy of Aesthetics**3 0 3**

Fundamental questions related to art, its purpose and manifestations as well as foundational problems such as, ideology, ontology, values attached, implicit/explicit meanings, connections with other disciplines, social manifestations and implications, historical contexts, mediums and representations. Important Indian and Western perspectives on aesthetics through music, literature, painting and cinema, contextualizing them in history.

HSS F354 Introduction to Islamic Economy**3 0 3**

Islamic Finance and Islamic digital economy, Halal industries, Halal tourism, Islamic art and design, Islamic economy standards and certification, and Islamic information and education.

HSS F355 Dictatorship, Democracy & Development**3 0 3**

Overview of the relationship between political regimes and development; how regimes matter: top-down interventions and bottom-up pressures; key concepts: democracy, dictatorship, civil society, social movements, social capital, human development; survey of academic literature to understand "democracy advantage"; country studies: Brazil, China, India; relevance and limitations of the relationship between political regime type and development.

HSS F356 Social Movements and Protest Politics**3 0 3**

Need for studying social movements ; origins, forms, trajectory, outcomes of social movements ; key participants; protestors objectives, their achievements / failures ; the Civil Rights Movement ; women's movements in the US and Europe; pro-democracy movements in Brazil; Islamic movements in the Middle East; The Christian Right in the US; the Hindu nationalist movement in India ; Maoism in India; anti-corruption protests.

HSS F361 Urban Policy and Governance**3 0 3**

Urban, urbanization, urbanism- the concepts; Major schools of thought in urban sociology; Patterns of urbanization- World urbanization, third world and India; Urban processes- assimilation, segregation, differentiation, suburbanization, Core-periphery, urban sprawl, primate city, right to city; Factors of urbanization- Natural growth, migration and re-classification; The constitutional and political dimensions of urbanization in India; Urban growth in post-

liberalization era and informal economy in cities; Urban problems; Urban policy history in India and contemporary policy measures; Future of urbanization in India.

HSS F362 Local Governance and Participation**3 0 3**

Political role of Panchayat Raj - Decentralisation below state level, Decentralised planning, Panchayati Raj Bills, Acts and Constitutional amendments, Grassroots politics; Inclusiveness and Participation - Women in Panchayati Raj, Impact of reservation in local bodies, Democracy and social capital, Local democracy and clientelism; Functional and Financial Devolution - Fiscal decentralisation to the sub-state level governments, Functional devolution to local bodies, Federalism, urban decentralisation and citizen participation, Poverty alleviation and efforts of panchayats; Challenges and Prospects of Local Government and Participation- Neighbourhood associations and local democracy, Experiment with direct democracy, Law of two-child norm in Panchayat, Beyond feminine public altruism.

HSS F363 Disaster and Development**3 0 3**

Disaster and Development - Concepts and contemporary debates, How disasters impact development, How development can induce vulnerability, Role of Planning in Disaster Management; Disaster Risk Assessment - Risk and Uncertainty, Multi-hazard analysis, Vulnerability and Capacity analysis, Risk evaluation and decision making; Mainstreaming Disaster Risk Reduction into Development - Mainstreaming of Frameworks and tools, Policies, Plans and Regulations, Challenges: data and modelling limitation, political and economic consideration; Disaster Management Planning - Need and impact assessment, Business Continuity Plan (BCP), Response and recovery planning.

HSS F364 Political Economy of Gulf Cooperation Council States**3 0 3**

Overview of Gulf History and Society: History in a nutshell; Religion, Language, Identity and Culture, Rentier State, Citizenship; Political and Social Change in the Gulf: Nationalism, Rule of Law and Political Liberalization, Gender and Participation; Media, Bureaucracy and Civil Society Groups; Economic Reforms and Governing Structure: State-Business Relations, Islamic Finance Development, Oil based Economy to Knowledge Economy, Resource Curse, Labour Market & Migration Policies; Internationalization of the Gulf: Security and Strategic Trends, Foreign Policy with International Reach, Environment, Energy, Maritime and Sustainable Policies, Challenges in transition.

HSS F365 Science of Sustainable Happiness**3 0 3**

Introduction to Science of Happiness; What Determines Happiness; Happiness Model and Model of Sustainable Happiness; Power of Social Connection; Managing Stress, Hardship, and Trauma; Living in the Present, Committing to Your Goals; Compassion and Kindness; Cooperation and Reconciliation; Mindfulness; Gratitude; Mental Habits of Happiness; If You are Depressed; New Frontiers and Happiness "Fit"; Five Hows Behind Sustainable Happiness; Sustainability, Happiness and Education.

HSS F368 Asian Cinemas and Cultures**3 0 3**

Introduction; The ideas of Asia; Asia as method; India and her neighbors; BRICS and ASEAN; Look East Policy; Cinema, Culture and Diplomacy; Cinema as Soft Power; Asian diaspora cinema; Indian Diaspora in the East; Cinemas from the Middle East; Iranian Cinema after the Revolution; Cinemas of & on the Israel-Palestine conflict-New Asian Metros; Thai Cinema and the global auteur; South Korean history through their Cinema; Filipino New-Wave, Taiwanese New Wave; Chinese Cinemas after the Cultural Revolution; Asianization of the West; India's Cine-Cultural Negotiations with her Asian Neighbors.

HSS F369 Caste and Gender in India**3 0 3**

Concepts - Caste and Gender; Materialist and religious theories; Caste Ideologies; Caste, class and gender intersections, Gender construction within castes; Graded Patriarchies; Colonial impact on caste and gender; Caste and Gender in contemporary period; Oppositional narrative to caste and gender construction; Legal interventions.

HSS F371 Cities-Life, Issues and Conflicts 3 0 3

The origin and growth of city; Theories and paradigms of cities; Spatial, socio-economic, political and cultural perspectives of cities; Social psychology of cities; Conflicts and changes within a city; City and the environment; Globalization impact on urban development in the Indian context.

HSS F372 Introduction to Social Psychology 3 0 3

Interaction between human and social situation; social environment and people and vice versa; fundamental theories; concepts; research methods in social psychology; past and present research related to social psychology; application of social psychological concepts to understand real life situation; social perception, social cognition; group dynamics; aggression; application of social psychology in law, health, and organizational sector; impact of social networking on life.

HSS F373 Shakespeare and Popular Culture 3 0 3

Renaissance political exigencies of government and theater; Shakespeare as popular culture in renaissance England; Shakespeare adaptations; case study of hamlet; the prince's right to govern; use of political force; early modern cultural expectations of the governed; renaissance individual's reliance of fortune; Machiavelli's The Prince; Castiglione's the book of the courtier. Recent popular representations of Hamlet; cotemporary relevance; nature of artistic composition; the discursive nature of the relationship between the past the present.

HSS F374 Urban Modernity and the Renewal of Paris 3 0 3

1850s – 1870s Street level reform; hygiene; circulation of capital; Modernity and Urban planning; theoretical background of urban planning; role of Baron Haussmann; notion of any modern city; political and artistic effects of urban planning; advertising and modern consumer culture in 1850s – 1870s.

HSS F375 Business and Politics in Colonial and Post Colonial India: a historical approach 3 0 3

Introduction to Indian Economic history; Dominant paradigms; Historical origins of Indian business, Caste, community networks and diaspora in early modern India and the Indian Ocean; Workings and impact of colonial rule on the Indian economy; Industrialization in India- challenges and way forward; Bazar economy; Indian capitalism; Business and Politics; Premier business houses and their strategies. The Informal sector; Business in new India.

HSS F378 Cinemas of India: From Past to Present 3 0 3

The emergence of cinema in India; early cinematic forms in India; the studio era; the rise of language cinema in India; social and mythological as popular film genres; melodramatic mode of Indian cinema; national and regional cinemas from India; Indian cinema and modernity; realism and Indian cinema; Indian new wave; Indian documentary films; star system and cine-politics; corporatisation of Indian film industries; media convergence and Indian cinema; gender and figuration in Indian cinema; Indian cinema after digital turn; indie cinematic practices from India.

HSS F379 Introduction to Philosophy of Science 3 0 3

Introduction; Philosophy and science, Science and pseudo-science, Focal questions of philosophy of science, Philosophical roots of science; ancient and modern, Nature of scientific reasoning; deduction and induction, Problem of induction, Inference to the best explanation; arguments for and against, Induction-Probability connection; Scientific explanations; Causality, Metaphysics of science; realism and anti-realism, Scientific change and scientific revolutions; Kuhn - paradigm shift, incommensurability, theory-ladenness; Philosophical problems in science; Physics – absolute space, Biology – species problem and classification, Psychology – Architecture of mind; Criticism of science; Values in science.

HSS F380 Performance Studies 3 0 3

Meanings and Constituents of Performance Studies; Performance: Characteristics and Signification; Ritual: Definitions and

Nuances; Play: Essence and Purposes; Performativity: Significance and its Embodiments; Orature and Cyberture; Intercultural and Global Performances.

HSS F381 Environmental Sustainability Ventures 3 0 3

Knowledge on climate ecosystem - Climate science and environmental challenges, Green and sustainable technologies, Regulatory and policy landscape in the climate sector, Sustainable business models and circular economy principles, Measuring and reducing carbon footprints, Climate finance and impact investment; Comprehensive business plan; Technoeconomic analysis; Enterprise financial model; Investor returns analysis; Market entry strategy; Growth Plan; Customer interviews; Problem statement definition - Target market, market size, initial market, Product & competition analysis, Go-to-market/commercial plan, Financial projections, Intellectual Property, Team, Elevator pitch

HSS F382 Housing: programs, policies and practices 3 0 3

Field of housing in the Global South; the role of state and non-state actors in development, delivery, and regulation of housing; economic, political, legal, and social forces that shape housing stock; the roles of economics of supply and demand, social policy framework, financing, and rights-based approach; the impact of patterns of governance; Housing processes related to indigenous people, migrant populations, rural and remotely accessible regions; difficulty in accessing appropriate housing with respect to certain populations.

HSS F383 Introduction to Museum Studies 3 0 3

Origin of Museums; "Antique" vs. Artifact ; Semiotics/Objects; Historical Meaning of Objects; Material Culture and Museum Objects; Commodities, Objects and their Value; Decolonization/ Settler-histories; Scientific collections & Colonialism ; Colonialism and Indian Museums; ; National Museums" in India ; Ethnic museums

HSS F384 Indian National Movement 3 0 3

Indian renaissance; birth of the Indian national congress and progress of Indian nationalism; moderates and extremists rise of communal politics; Gandhi and the non-cooperation movement; swaraj party; Simon Commission and the Nehru report; civil disobedience and the Round Table Conferences; World War II and the constitutional deadlock; Cripps proposals; Quit-India Movement; CR formula and the Wavell Plan, Cabinet Mission Plan; Netaji Subhash Chandra Bose and the I.N.A., Mountbatten Plan-India divided; the aftermath.

HSS F385 Mental Health Literacy for Youth 3 0 3

Understanding mental health; Myths vs. facts about mental illness; Biomedical vs. biopsychosocial model of mental health; Stigma and its effects on help seeking behaviour; Cultural diversity and cultural competence; Understanding common mental health issues; Mental health challenges faced by youth; Overview of depression, anxiety (panic disorder and stress), bipolar disorder, schizophrenia, eating disorders, OCD, PTSD, substance abuse, personality disorders, and childhood disorders; Mental health in the digital age; Social media; Cyberbullying; Digital well-being; Technology addiction; Online privacy; Nomophobia; Mental health support and resources; Mental health first aid; Crisis intervention; Seeking help; Community resources; Global mental health; Legal and ethical considerations; Healthcare systems; Mental health advocacy; Applied mental health literacy and advocacy

HSS F386 Ocean Humanities 3 0 3

Introduction to Ocean Humanities and Blue Humanities; Ocean and the Novel, Nautical Fiction, Maritime and Oceanic kinship, Hydro- feminism, concept of Hydrocolonialism, folklores and ballads involving maritime trade and ship building activities, Diaspora in Indian Ocean and the concept of Oceanic Feeling or Consciousness by Rolland Romain and Freud, Cosmopolitanism in Port cities, Ocean in other Cultural Productions- Films and Music.

HSS F399 Introduction to American Literature 3 0 3

Socio-cultural and literary history of the United States since the landing of the Pilgrims from *The Mayflower* to the decisive American victory over the Axis powers in World War II. (1500-1700)

Establishment of Plymouth Plantation and the establishment of early Puritanism. (1700-1800) Influence of Enlightenment thought on American life and letters and Consequences of the Revolutionary War on literature. (1800-1865): American Literary Nationalism, the westward expansion, and the American Civil War. (1865-1914): Reconstruction period, Mexican War, imperial expansion to the Southwest, building of transcontinental railroads, the American frontier issue, industrialization and transformation of American life and their effects on the literary marketplace. (1914-1945): the two world wars, the Great Depression, Modernism and Modernity in American life and letters, Harlem Renaissance, increasing presence of science and technology in everyday American life.

HSS G511 Philosophical Foundations of Liberal Studies 3 2 5

Idea of being; modes of being; causation; metaphysics; education; natural education; social education; refutation of metaphysics; concept of necessity; humanism; epistemology; search for the method of science; Reasoning – constructing Arguments-Standards for constructing and evaluating arguments; validity, truth, and soundness; Fallacies; Project

HSS G512 Theoretical Approaches to Liberal Studies 3 2 5

Introduction to Ideologies in Social Sciences; Developmentalism, Political Culture, Sociological approaches; Psychoanalysis as bridging the fields of humanities, natural and social sciences; Institutions and institutionalism; Irrationalism; Environmentalism; Sociobiology; The present as past; Culture, Intellectuals and Media; Indigenous theories of change; Project

HSS N201T Intro to Photography* 3 0 3

HSS N202T Ind C Dance Bharatnatyam* 3 0 3

*Course Description is to be developed

HSS N203T Basic Arabic 3 0 3

Arabic of basic level, Recognition of Arabic alphabets with its different writing patterns, Phonetics and peculiar Arabic sounds, Familiarity with the basic vocabulary, Familiarity with profession specific words and phrases, Grammar, Sentence patterns and expressions for daily communication, Reading, writing, listening and speaking skills at initial level, Focus on modern standard Arabic and its comparison with colloquial and local dialect, exercises and practice.

HSS N301T Elements of Dance 1 1 2

Introduction to elements of dance; dance sense; dance pathway; relationship of dance with culture, society, geography and arts; dance workout, salsa, ballet, folk, classical, contemporary, musical theatre

Humanities

HUM G511 Introduction to Health Systems 3 0 3

Health facilities for SC/ST; Health Systems; Evolution of Medicine; Sociology, health and medicine; Primary health care; Health Development; Health education; Health policy in India; Issues like euthanasia, consumer forums, child labor; Female infanticide; women's health; Role of hospitals; Advances in Public Health; Communications; Evaluation of National Health Systems; Demography; Family Planning; Psycho-social issues.

Instrumentation

INSTR F211 Electrical Machines 3 1 4

Transformer: Constructional features, equivalent circuit and phasor diagram - regulation and efficiency, parallel operation. Three phase transformer connections; Harmonic in transformers; Testing; Phase conversion; Autotransformer. D.C Machines: Construction, armature windings, armature voltage and torque equations, classification. D.C generators, performance characteristics; D.C motors - torque/speed characteristics, speed control and braking. Testing and efficiency. Induction machines: Constructional features and rotating magnetic field. Circuit model and phasor diagram. Steady state characteristics. Testing, starting and speed control. Time harmonics and space harmonics. Wound

rotor induction motors, Single phase induction motors - classification and equivalent circuit. Synchronous machines: Constructional features; synchronous generators and motors; equivalent circuit and phasor diagram; power and torque characteristics and capability curves. Parallel operation. Salient pole synchronous machine - phasor diagram and determination of synchronous reactances; starting and speed control of synchronous motors. Special machines universal motors, Induction generators.

INSTR F212 Electromagnetic Theory 3 0 3

Review of mathematics - scalar and vector fields, calculus of scalar and vector fields in Cartesian and curvilinear coordinates, Dirac delta function; Electrostatics - electric field, divergence & curl of electric field, electric potential, work and energy in electrostatics, conductors, electric dipole; Electrostatics in Matter - polarization and field of a polarized object, electric displacement, linear dielectrics; Magnetostatics - Lorentz force law, Biot-Savart law, divergence & curl of magnetic field, magnetic vector potential, magnetic dipole; Magnetostatics in matter - magnetization and field of a magnetized object, the H-field, linear & non-linear magnetic media; Electrodynamics - electromotive force, electromagnetic induction, Maxwell's equations in free space, plane wave solutions of Maxwell's equations in free space.

INSTR F214 Electronic Devices 3 0 3

Crystal structure and growth of semiconductor, electrical conduction in solids, Elementary quantum physics (Photoelectric effect, uncertainty principle, Schrodinger wave equation and tunneling), energy bands in solids, charge carriers in semiconductors, excess carriers in semiconductors, Fabrication of p-n junctions, equilibrium conditions, forward and reverse biased junctions, metal semiconductor junctions Bipolar junction transistors, field effect transistors (JFET, HEMT, MOSFET), Special diodes (varactor diode, solar cell, LEDs, Tunnel diode and HBT), dielectric materials and insulation (Polarization mechanisms, frequency dependence, dielectric strength and insulation breakdown).

INSTR F215 Digital Design 3 1 4

Boolean Algebra & logic minimization; combinational logic circuits : arithmetic circuit design , Design using MSI components; Sequential Logic Circuits : flip flops & latches, registers and counters, Finite state machine ; HDL Implementation of Digital circuits; Digital Integrated Circuits; Programmable logic devices; Memory organization ; Algorithmic State machine; Introduction to computer organization; The course will also have laboratory component on digital design.

INSTR F216 Electronic Devices Simulation Laboratory 0 2 2

Hands on simulation experience of Electronic Devices (Diodes, BJTs, MOSFET and MOS Capacitor) using Sentarus TCAD; Simulation of electrostatics of various Electronic Devices and their effects on the device performance.

Pre-requisites:

EEE F214 / INSTR F214 / ECE F214 : Electronic Devices

INSTR F241 Microprocessors and Interfacing 3 1 4

Programmers model of processor, processor architecture; Instruction set, modular assembly programming using subroutines, macros etc.; Timing diagrams; Concept of interrupts: hardware & software interrupts, Interrupt handling techniques, Interrupt controllers; Types of Memory & memory interfacing; Programmable Peripheral devices and I/O Interfacing ; DMA controller and its interfacing: Design of processor based system. This course will have laboratory component.

INSTR F242 Control Systems 3 0 3

Modeling and classification of dynamical systems, Properties and advantages of feedback systems, time-domain analysis, frequency-domain analysis, stability and performance analysis, State space analysis, controller design.

INSTR F243 Signals & Systems 3 0 3

This course is intended to provide a comprehensive coverage of Signals and Systems, a fundamental subject of Electrical Engineering. The topics covered are: Continuous-time and discrete time signals and systems, convolution, properties of linear time-

invariant (LTI) systems, Fourier series, Fourier transform, Z transform, Laplace transform; System analysis, frequency response, analog filters, Sampling and reconstruction.

INSTR F244 Microelectronic Circuits 3 0 3

Basic microelectronic circuit analysis and design, biasing in discrete and integrated circuit amplifiers, an overview of modeling of microelectronic devices single and two transistor amplifier configurations with passive and active loads; current mirrors & current sources; single-ended and differential linear amplifiers, differential and multistage amplifiers; 2 stage CMOS OPAMP, frequency response of amplifiers; negative feedback in amplifiers, R-C frequency compensation.

INSTR F266 Study Project 3

These courses include projects which are oriented towards readings from published literature or books about new frontiers of development or analysis of available database. These courses are normally available to students in second or higher levels. These courses must coterminate with project reports.

INSTR F311 Electronic Instrumentation & Instrumentation Technology 3 1 4

Electronic indicating, display, recording and analysis instruments, signal generators, frequency synthesizer, counters, elements of design, grounding and shielding, electronic circuits manufacturing technology, metrology, standards in quality management, instrumentation in hazardous area, industrial communication techniques.

INSTR F312 Transducers and Measurement Systems 3 0 3

Importance and types of measurement, generalized measurement system, functional elements, static & dynamic characteristics, primary sensing elements, passive transducers, active transducers, inverse transducers, fiber optic transducers, MEMS based transducers, measurement techniques for motion, seismic, pressure, flow, temperature, level, humidity, pH, viscosity; signal conditioning techniques using bridge, op-amp, instrumentation amplifier, carrier, chopper, charge, isolation amplifier, data converters, filters, modulators; data acquisition systems.

INSTR F313 Analog & Digital VLSI Design 3 0 3

Moore's Law, Y chart, MOS device models including Deep Sub-Micron effects; an overview of fabrication of CMOS circuits, parasitic capacitances, MOS scaling techniques, latch up, matching issues, common centroid geometries in layout. Digital circuit design styles for logic, arithmetic and sequential blocks design; device sizing using logical effort; timing issues (clock skew and jitter) and clock distribution techniques; estimation and minimization of energy consumption; Power delay trade-off, interconnect modelling; memory architectures, memory circuits design, sense amplifiers; an overview of testing of integrated circuits. Basic and cascaded NMOS/PMOS/CMOS gain stages, Differential amplifier and advanced OPAMP design, matching of devices, mismatch analysis, CMRR, PSRR and slew rate issues, offset voltage, advanced current mirrors; current and voltage references design, common mode feedback circuits, Frequency response, stability and noise issues in amplifiers; frequency compensation techniques.

INSTR F341 Analog Electronics 3 1 4

Introduction to operational amplifiers: The difference amplifier and the ideal operational amplifier models, concept of negative feedback and virtual short; Analysis of simple operational amplifier circuits; Effects of real operational amplifier parameters on circuit performance. Linear applications of operational amplifiers: Instrumentation and Isolation amplifiers; Current and voltage sources; Active filters. Non-linear applications of operational amplifiers: Comparators; Linearization amplifiers; Logarithmic amplifiers, multifunction modules & circuits, true rms converters, Precision and signal conditioning circuits, Waveform Generation: sinusoidal and non-sinusoidal signal generation; Wave shape converters. Timer 555 based circuits, Phase lock loop circuits & applications, IC regulators, Output stage and large signal amplifiers, Power amplifiers, Tuned amplifiers, Analog and Digital interface circuits: A/D, D/A Converters.

INSTR F342 Power Electronics 3 1 4

Need for power conversion; Power electronic converters: classifications and scope; Power semiconductor switches: diodes, SCR, GTO and transistors (BJT, MOSFET and IGBT): Ratings, static and dynamic characteristics, drive and switching aid circuits and cooling; DC to DC conversion: Buck, Boost and Buck-Boost converters: circuit configuration and analysis with different kinds of loads; Choppers: single quadrant and two quadrant operation with DC motor load and steady state analysis; Rectifiers: single phase and three phase operation, power factor, harmonics and effect of source inductance; Dual converters; Drive concept: Four quadrant drive and load characteristics, selection of motor, control and stability of electric drives, feed back control of drives; DC motor drive; Inverters: single phase and three phase bridge inverters and PWM inverters; Single phase AC voltage regulators and cycloconverter; Induction motor drive - Variable frequency operation of 3-phase induction motor, stator voltage control and V/f control methods; Non-drive application of power electronic converters: UPS, active power line conditioner, electronic ballast and induction.

INSTR F343 Industrial Instrumentation and Control 3 0 3

Importance of process control, elements of process loop, mathematical modeling, dynamic closed loop characteristics, controller principles & tuning, direct digital loop, hydraulic controllers, pneumatic controllers, electronic controllers, complex & multivariable control schemes, final control elements, P & I diagrams, PLCs, Distributed Control Systems (DCS), AI techniques: expert systems, neural networks, fuzzy logic, genetic algorithms & applications.

INSTR F366 Lab Project 3

INSTR F367 Lab Project 3

These courses include projects involving laboratory investigation or laboratory development in the students discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

INSTR F376 Design Project 3

INSTR F377 Design Project 3

These courses are intended to impart training in design of product/ process or other artifact to the students in the discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

INSTR F411 Opto-Electronic Instruments 3 0 3

Optical radiation-its emission, control and detection; optical signal processing; amplifiers and associated electronic equipments. Opto-electronic system design-calorimeters, spectrophotometers, flame photometers, fluorimeter and turbidimeters; project equipments; introduction to laser-based instruments.

INSTR F412 Analysis Instrumentation 3 0 3

Generalized configuration of an analysis instrument. Off-line analysis instruments: emission spectrometers, UV/VIS/IR absorption spectrophotometers, flame emission and atomic absorption spectrophotometers, X-ray fluorescence spectrometer and diffractometer, NMR and mass spectrometers, pH-meters, gas chromatographs, electrochemical instruments, analytical electron microscopes. On line analyzers: Sampling systems for gases and liquids, fluid density monitors, consistency and viscosity analysers, thermal conductivity gas analysers, paramagnetic oxygen analysers, chemical composition analysers, on-line instruments for measuring standard parameters, e.g. vapour pressure, distillation characteristics, cloudpoint, pour point, flash point etc. Recent developments.

INSTR F413 Advanced Process Control 3 0 3

Process identification and adaptive control; Model predictive control structures; Model-based control structures; State estimation; Synthesis of control systems-some case studies; intelligent control.

INSTR F414 Telecommunication Switching Systems & 3 0 3 Networks

Introduction, electromechanical switching, pulse dialing and DTMF dialing, stored program control, space division switching, speech digitization and transmission, time division switching, fundamentals of traffic engineering, telephone networks, signaling, data networks, layered architecture and protocols, LANs, packet switching networks, TCP/IP, ISDN, ATM networks.

INSTR F415 Digital Control 3 0 3

Course Description is to be developed.

INSTR F419 Virtual Instrumentation 3 1 4

Fundamentals of virtual instrumentation--- Concept of virtual instrumentation – PC based data acquisition – Typical on board DAQ card – Resolution and sampling frequency - Multiplexing of analog inputs – Single-ended and differential inputs – Different strategies for sampling of multi-channel analog inputs. Concept of universal DAQ card - Use of timer-counter and analog outputs on the universal DAQ card. Concepts of graphical programming – Lab-view software – Concept of VIs and sub VI - Display types – Digital – Analog – Chart – Oscilloscopic types – Loops – Case and sequence structures - Types of data – Arrays – Formulae nodes –Local and global variables – String and file I/O., Analysis tools and simple applications :Fourier transform - Power spectrum - Correlation – Windowing and filtering tools – Simple temperature indicator – ON/OFF controller – P-I-D controller - CRO emulation - Simulation of a simple second order system.

INSTR F420 Design of Instrumentation Systems 3 0 3

Design of transducers, signal conditioning circuits, instrument air system, control valve, control panel design, Human machine interface, Reliability, Electronic product design, Noise reduction, P&I diagrams, safety instrumentation systems, life cycle activities: requirement specifications, I&C system design and implementation, system integration, validation, operation maintenance, case studies of ISD in various sectors.

INSTR F422 Instrumentation for Petrochemical Industry 3 0 3

Petroleum Processing: Petroleum exploration – Recovery techniques – Oil - Gas separation –Processing wet gases - refining of crude oil, Unit Operations in Petroleum Industry: Measurement in Petrochemical Industry: Parameter to be measured in refinery and petrochemical industry – Selection and maintenance of measuring instruments – Intrinsic safety of instruments Control Loops in Petrochemical Industry: Process control in refinery and petrochemical industry – Control of distillation column control of catalytic crackers and pyrolysis , Automatic control of polyethylene production – Control on vinyl chloride and PVC production.

INSTR F423 Electronic Material Design and Simulations Laboratory 1 2 3

Reviewing the basic Theory for Crystalline Solids (Crystal group, real Space, reciprocal space), Introduction of the Concept of Density Functional Theory (Many Electron Scenario, Born-Oppenheimer Approximation, Hartree's Formulation, Hohenberg and Kohn Theorems, Energy Functional, Kohn Sham Scheme), Familiarization with Quantum Espresso (Plane Wave Basis Set, Exchange Correlation Functional, Pseudopotential, Brillouin Zone Sampling, Quantum Espresso input file format), Theoretical Calculation of Structural Properties of Materials (Unit Cells and Super Cells, Lattice Vectors, Ground-state Energy, Bond-Length and Bond Angles), Theoretical Calculation of Electronic Properties of Materials (Energy Band Profiles and Density of States, Projected Density of States), Theoretical Calculation of Optical Properties of Materials (Optical Spectrum), Introduction of Doping in Materials (Effects on Electronic and Optical Properties), Introduction of Strain in Materials (Effects on Electronic and Optical Properties) Simulation of 2D materials like Graphene and MoS₂.

Pre-requisites:

EEE F214 / INSTR F214 / ECE F214 : Electronic Devices

INSTR F424 Smart Grid for Sustainable Energy 3 0 3

Introduction to Smart grid, Renewable Power Generation and Energy Storage, Microgrid, Power System Economics and Electricity Markets, Demand Response, Various Sensing, Communication, and Control technologies, and Application of Data Science.

Pre-requisites:

EEE F242 / INSTR F242 / ECE F242 : Control Systems

INSTR F428 Energy Storage Systems 3 0 3

Need of Energy Storage; Broad classification of Energy Storage Systems and applications; Electrochemical Energy Storage Systems; Battery Storage; Application oriented choice of Batteries; Electrical interface system design for Batteries with Renewable Energy sources; Battery Management Systems (BMS); Hydrogen Energy Storage; Its application as Fuel cell, Electrical Energy Storage; Thermal Energy Storage; Mechanical Energy Storage and their applications.

INSTR F432 Medical Instrumentation 3 0 3

Basic components of bio-medical instruments, bio-electric signals & recording electrodes, transducers, recording and display devices. Patient care and monitoring systems, cardiovascular measurements-blood pressure, blood flow, cardiac output, heart sounds etc.; instrumentation for respiratory and nervous systems, analysis of EEG, ECG, EMG, EOG and action potentials, non-invasive diagnostic measurements - temperature, ultrasonic diagnosis, CAT scan techniques, sensory measurements-motor response, analysis of behaviour etc. biotelemetry, biofeedback, clinical laboratory instruments, X-ray diagnosis. Recent advances in biomedical instrumentation- microprocessor based systems, lasers & optical fiber based systems.

INSTR F473 Wind Electrical Systems 3 0 3

Thermodynamics of wind energy, Types of Wind energy conversion devices, Aerodynamics of wind rotors, design of wind turbine rotor, Power -speed characteristics, torque-speed characteristics, Wind turbine control systems, Wind speed measurements , Wind speed statistics, Site and turbine selection, Induction Generators, Wound field synchronous Generator, Permanent Magnet synchronous machine, Doubly fed induction generator, Power Flow equations, Power Semiconductor devices, Converters, Inverters, power quality, Reactive power compensation, Wind diesel hybrid systems, Wind photovoltaic systems, Role of Govt. and policies for market development.

INSTR F491 Special Project 3

This is an unstructured open-ended course where under the overall supervision of an instructor-in-charge, batches of students will be attached to different instructors. Each batch will work on a specific time-bound project which is of basic or peripheral concern of his discipline. Each student must submit a project report as a culmination of his endeavour and investigation. The instructor-in-charge will determine the choice of the project and also whether or not the project report is to be submitted jointly by a group or individually by a student. The course will aim to evaluate student's actual ability to use the fundamentals of knowledge and to meet new unknown situations as demonstrated by the students' interaction with the instructors and instructor-in-charge and aggregated in the project report. The instructor-in-charge may assign specific hours for formal brain-storming sessions.

INSTR G611 Advanced Control Systems 3 2 5

Review of State variable modelling of linear continuous, linear discrete and non linear control systems; Time varying systems; Time domain solution; Controllability and observability; Stability; direct method of Lyapunov; Modal control; Optimal Control System; Calculus of variation, Minimum principle, dynamic programming, search techniques, Ricatti equation, Stochastic processes and Stochastic estimation and control; Adaptive Control system.

INSTR G612 Instrumentation Systems 3 2 5

Generalized approach to measuring systems; performance characteristics of instruments; primary sensing elements and transducers; analog and digital signal conditioning operations; micro-processors in instrumentation; applied process control instrumen-

tation; General purpose and analytical instruments covering spectroscopic, separation, atomic absorption instruments UV-VIS-IR, GLC, HPLC, etc; Instrumentation practices in typical R&D laboratories; instrumentation case studies covering selection, quality assurance, system design, etc; Hands on experience in operation of sophisticated instrumentation systems.

INSTR G621 Industrial Automation

3 2 5

Computer control theory, sampling of continuous time signals, computer oriented mathematical models, discrete time systems, and analysis of the same, translation of analog design, state space design methods, pole-placement design based on input/output models. Adaptive control principles, implementation of digital controllers, model reference adaptive systems, self-tuning regulators, stochastic adaptive control, auto-tuning, expert controllers, learning systems and other applications.

Information Systems

IS F211 Data Structures & Algorithms

3 1 4

Introduction to Abstract Data Types, Data structures and Algorithms; Analysis of Algorithms – Time and Space Complexity, Complexity Notation, Solving Recurrence Relations.; Divide-and-Conquer as a Design Technique; Recursion – Recursive Data Types, Design of Recursive Functions / Procedures, Tail Recursion, Conversion of Recursive Functions to Iterative Form. Linear data structures – Lists, Access Restricted Lists (Stacks and Queues); Searching and Order Queries. Sorting – Sorting Algorithms (Online vs. Offline, In-memory vs. External, In-space vs. Out-of-space, Quick Sort and Randomization), Lower Bound on Complexity of Sorting Algorithms. Unordered Collections: Hash tables (Separate Chaining vs. Open Addressing, Probing, Rehashing). Binary Trees – Tree Traversals. Partially Ordered Collections: Search Trees and Height Balanced Search Trees, Heaps and Priority Queues. Probabilistic/Randomized Data Structures (such as Bloom Filters and Splay Trees). Generalized Trees – Traversals and applications. Text Processing – Basic Algorithms and Data Structures (e.g. Tries, Huffman Coding, String search / pattern matching). External Memory Data structures (B-Trees and variants). Graphs and Graph Algorithms: Representation schemes, Problems on Directed Graphs (Reachability and Strong Connectivity, Traversals, Transitive Closure. Directed Acyclic Graphs - Topological Sorting), Problems on Weighted Graphs (Shortest Paths. Spanning Trees).

IS F213 Object Oriented Programming

3 1 4

Object orientation concepts, theories and principles; fundamental concepts of the object model: classes, objects, methods and messages, encapsulation and inheritance, interface and implementation, reuse and extension of classes, inheritance and polymorphism; overloading and overriding; static and dynamic binding; multithreaded programming; event handling and exception handling; process of object oriented requirements specification, analysis and design; notations for object-oriented analysis and design; case studies and applications using some object oriented programming languages. Object Oriented Design Patterns: Behavioral, Structural and Creational.

IS F214 Logic in Computer Science

3 0 3

Propositional logic – syntax, semantics, satisfiability & validity, predicate or first order logic – syntax, semantics, satisfiability & validity, completeness & compactness, Undecidability & incompleteness; Godel's incompleteness theorem; SAT solvers; verification by model checking, linear-time temporal logic (LTL), & computational tree logic (CTL). Program verification using Hoare logic & proofs of correctness; Modal logic & logic programming paradigm.

IS F222 Discrete Structures for Computer Science

3 0 3

Sets & operation on sets; relations & equivalence relations; number theory; weak & strong form of mathematical induction; principle of inclusion & exclusion, pigeonhole principle; recurrence relations & generating functions; digraphs & graphs, graph isomorphism & sub-graphs, spanning trees, Euler & Hamiltonian graphs, planar graphs, chromatic numbers & graph coloring; groups; Lagrange theorem finite groups; Rings & Fields.

IS F241 Digital Electronics and Microprocessors

3 1 4

Binary logic gates; logic circuits; Boolean algebra and K-map simplification; number systems and codes; arithmetic logic units; flipflops; registers and counters; introduction to microprocessors; architecture; instruction set and programming; memory and I/O interfacing; examples of system design.

IS F242 Computer Organization

3 1 4

This course covers the fundamentals of computer organization and architecture. Computer system components; Interconnection structures; Instruction set architecture; Computer arithmetic; Memory system; I/O systems; Control unit design; Instruction execution and scalar pipelining; Parallel processing and Super scalar pipelining; Introduction to parallel processing architecture including multi-core systems.

IS F243 Database Systems & Application

3 1 4

Introduction to Database Management Systems; Data Independence in databases; DBMS architecture; Data Models; Relational Model; Query Languages: Relational Algebra and SQL, Database Design techniques; Normalization; Data Organization; File Systems and Indexing; Concepts of security and integrity in databases; Transaction Processing ; Query processing and optimization; DBMS based application development; internet applications XML data management; multimedia databases; Distributed Databases.

IS F266 Study Project

3

These courses include projects which are oriented towards readings from published literature or books about new frontiers of development or analysis of available database. These courses are normally available to students in second or higher levels. These courses must coterminate with project reports.

IS F301 Principles of Programming Languages

2 0 2

The course covers features of programming languages and introduces the main programming paradigms. It covers, in detail, the semantics of the features of programming languages –Control Abstraction, Data Types and Data Abstraction, Scope and Parameter passing and Concurrency related features. It covers various aspects of runtime environments like global and local data, code, function call stacks, dynamically allocated data, runtime features for exceptions and threads. Introduction to programming paradigms. Functional paradigm – formal elements of lambda calculus, introduction to syntax of common functional programming languages and programming exercises that explore the functional paradigm. Logic programming paradigm - formal elements of logic programming and programming tasks that explore the logic paradigm. Scripting as a paradigm. Domain specific languages. Applications of the principles of programming languages –program verification, software testing and security.

IS F303 Computer Networks

3 1 4

Introduction; Need for Computer Networks; Top-down vs. Bottom-up approaches; Network Services, and Protocols; Network Reference Models and Architectures, Architecture of the Internet, Types and Applications of contemporary and emerging Networks, Application-Layer Requirements, Concepts, Services and Protocols: Protocols for Web, Email, File transfer, Name Resolution, Address Assignment / Discovery, Remote Access Services, Voice/Video over IP, Webcasting, Video-Conferencing and Telepresence, Network Management Protocols and Overlay Networks; Transport Layer Requirements, Services, Concepts and Protocols; Network Layer Requirements, Concepts, Services and Protocols, Routing vs. Layer-3 Switching; QoS; Link Layer and Physical Layer Requirements, Concepts, Services and Protocols, Logical Link and Medium Access Control concepts, Physical medium dependent function, Modes of Signaling and Communication at the lower layer; IEEE 802 architecture, Bridging versus Layer-2 Switching; VLANs, VPNs, Performance vs. Security, Emerging Trends and Best Practices related to design of computer networks and internetworks.

IS F311 Computer Graphics**3 0 3**

Graphics I/O hardware; Generation of dot, lines, conics, curves, surfaces & polygons; Filling closed regions, 2D & 3D Graphics & Transformations, Windowing, Viewing & Clipping, Efficient algorithms, Solid Modeling, Color Models & Dithering, Visible surface detection, Rendering, Animation Techniques, Advanced modeling and Future directions.

IS F322 Software Testing**2 1 3**

Brief description of importance of software, Life cycle model and process, Basic software testing, all definitions, Types of testing and techniques (CFG, CDG etc.), Black Box & white box Testing Methodologies, Finite State Machine Model, State based Testing, Static Testing and analysis, Test cases, Test Data Generation, Test selection, Minimizations and Prioritization, Test adequacy criteria, Software Testing on Web Engineering, Object based Software Testing, Architecture of Testing tool, Software Test Effort Estimation, Testing behavior and process model, Qualitative analysis, Quality factors in software testing, Selection of testing tools.

IS F341 Software Engineering**3 1 4**

Ethics of software Engineering (ACM/IEEE code of Ethics), Type of Software, Application of Software, Software Life Cycle Model, Agile Modeling Requirement Engineering, Object Oriented Analysis and Design (using UML), Introduction of Web Engineering, Software Integration and Testing, Support Processes and Software Quality, Software change Management, Software Product and Process Metrics Measurement, Software Project Management, Scheduling, Staff Measurement, Risk Management, Component based Software Engineering, Quality and Reliability Model, Maturity Models, Software Reengineering, deployment models.

IS F342 Compiler Design**2 1 3**

Introduction - Compilation and Execution Environments - Compilers and Interpreters - Requirements and Motivation; Front-end and Back-end of compilers/interpreters; Intermediate Representation and Intermediate Languages; Compile Time vs. Execution Time; Translators, and Assemblers; Virtual Machine -Just-in-Time Compilers. Structure of a Compiler - Phases and Passes. In-memory data - intermediate versions of code, symbol table. Lexical Analysis: Regular expressions and DFA (introduction where needed), Defining tokens using regular expressions, Designing and implementing scanners / lexical analyzers. Parsers: Context Free Languages (introduction where needed) and Recognizing CFLs. Parsing techniques - LL, LR - LR (0), LR(1), LALR. Intermediate Representation: Parse Trees and Abstract Syntax Trees; 3-address code. Semantic Analysis. Back End Phases: Machine Independent optimizations: Loop Optimization Techniques - Loop Unrolling, Induction variable based optimization, Loop-Invariant code elimination. Procedure Call Optimization, and Dead Code Elimination. Target Code Generation: Data Flow Analysis, Register Allocation, Instruction Selection & Scheduling. Memory Management: Memory allocation support, Memory-de-allocation - Garbage Collection Techniques. Advanced Topics: Issues in compiling Object Oriented Languages, Functional Languages, Concurrent Languages, Script & Query Languages.

IS F366 Lab Project**3****IS F367 Lab Project****3**

These courses include projects involving laboratory investigation or laboratory development in the students discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

IS F376 Design Project**3****IS F377 Design Project****3**

These courses are intended to impart training in design of product/ process or other artifact to the students in the discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

IS F372 Operating Systems**3 0 3**

Introduction to operating systems; Various approaches to design of operating systems; Overview of hardware support for Operating systems; Process/thread management: synchronization and mutual exclusion, inter process communication, CPU scheduling approaches; Memory management: paging, segmentation, virtual memory, page replacement algorithms; File systems: design and implementation of file systems; Input /Output systems; device controllers and device drivers; Security and protection; Case studies on design and implementation of operating system modules.

IS F462 Network Programming**3 0 3**

Overview of computer networks; inter-process communication; network programming; socket interface; client-server computing model: design issues, concurrency in server and clients; external data representation; remote procedure calls; network file systems; distributed systems design.

IS F491 Special Project**3**

This is an unstructured open-ended course where under the overall supervision of an instructor-in-charge, batches of students will be attached to different instructors. Each batch will work on a specific time-bound project which is of basic or peripheral concern of his discipline. Each student must submit a project report as a culmination of his endeavour and investigation. The instructor-in-charge will determine the choice of the project and also whether or not the project report is to be submitted jointly by a group or individually by a student. The course will aim to evaluate student's actual ability to use the fundamentals of knowledge and to meet new unknown situations as demonstrated by the students' interaction with the instructors and instructor-in-charge and aggregated in the project report. The instructor-in-charge may assign specific hours for formal brain-storming sessions.

Internet Technology & e-Business**ITEB G621 Supply Chain Management****4**

Customer driven strategies in production and distribution systems; Integrated production & distribution networks; SCM in the context of JIT and MRP-II; Distribution Resource Planning; Management of dealer networks; Total Quality Control & product innovation across the supply chain; Incoming logistics & supplier relationships; Value addition analysis; Metrics for management of supply chain performance; Mathematical models and computer assisted decision support for SCM; mathematical programming for SCM.

Japanese**JAP N101T Beginning Japanese****3 0 3**

Basic Japanese scripts (Hiragana, Katakana and Kanji); constructing words using Hiragana and Katakana and understanding their meanings; forming sentences, understanding their meanings, learning the related Kanjis; listening and reading comprehension, conversion practice, revision and additional practice through audio cassettes.

Mathematics and Computing**MAC F211 Linear Algebra and Its Applications****3 0 3**

Quick Review of Vector Spaces and Linear Transformations: Basis and dimension, rank-nullity theorem, change of basis; Inner product spaces: Cauchy Schwarz's inequality, Orthonormal basis, Gram-Schmidt orthonormalization, QR decomposition, orthogonal projection with projection theorem, General Least-squares problem, Discrete Fourier Transform; Norms of vectors, functions, and matrices, matrix decompositions; Eigenvalues and eigenvectors, Diagonalization, Spectral Theorem, Cayley-Hamilton Theorem, Primary Decomposition theorem, Jordan canonical forms (without proof); Singular value decomposition and applications: Reduced SVD, norms, condition number, and Rank via SVD, Moore-Penrose inverse, Principal Component Analysis, and Lowrank approximations, least-squares solutions to linear systems.

Pre-requisites: MATH F112: Mathematics II

MAC F212 Object Oriented Programming 3 1 4

Object orientation concepts, theories, and principles; fundamental concepts of the object model: classes, objects, methods and messages, encapsulation and inheritance, interface and implementation, reuse and extension of classes, inheritance, and polymorphism; overloading and overriding; static and dynamic binding; multithreaded programming; event handling and exception handling; the process of object-oriented requirements specification, analysis, and design; notations for object-oriented analysis and design; case studies and applications using some object-oriented programming languages. Object Oriented Design Patterns: Behavioral, Structural, and Creational.

Equivalent: CS F213/IS F213: Object Oriented Programming

MAC F213 Discrete Mathematics 3 0 3

Set theory: Sets, relations and functions, equivalence relations, partially ordered sets, countability of sets, lattices and Boolean algebras; Logic and Methods of Proof: Propositional logic, language of propositional logic, predicate logic and logical inference with quantifiers, introduction to different standard proof techniques; Combinatorics: Counting techniques: pigeon hole principle, inclusion-exclusion principle, recurrence relation, and generating function, partitions, special numbers like Fibonacci, Stirling, and Catalan numbers (Just an introduction). Graph Theory: Graphs and digraphs, special types of graphs, trees, isomorphism, connectedness, Euler and Hamilton graphs, planar graphs, Graph Laplacian; graph colouring.

Equivalent: MATH F213: Discrete Mathematics

MAC F214 Elementary Real Analysis 3 0 3

Countability and uncountability of sets; real numbers; limits and continuity; compactness and connectedness in a metric space; Riemann integration; uniform convergence.

Equivalent: MATH F214: Elementary Real Analysis

MAC F241 Numerical Analysis 3 0 3

Principles of floating point computations and rounding errors; Systems of Linear Equations: factorization methods, pivoting and scaling, residual error correction method; Iterative methods: Jacobi, Gauss-Seidel methods with convergence analysis; Eigenvalue problems: algorithms with implementation issues; Nonlinear algebraic equation: root finding (bisection, secant, fixed point iteration and Newton-Raphson methods), nonlinear algebraic system (Fixed point iteration, Newton and Newton like methods); Interpolation: Lagrange interpolation techniques, piecewise linear and cubic splines, error estimates; Approximation: uniform approximation by polynomials, data fitting and least squares approximation; Numerical Integration: integration by interpolation, adaptive quadratures and Gauss methods; Initial Value Problems for Ordinary Differential Equations: Euler's method, single step Runge-Kutta methods, multi-step methods, predictor and corrector scheme, stability and convergence analysis. FDM for Two point BVP.

Equivalent: MATH F313: Numerical Analysis

MAC F242 Data Structures & Algorithms 3 1 4

Introduction to Abstract Data Types, Data Structures and Algorithms; Analysis of Algorithms, Time and Space Complexity, Complexity Notation, Solving Recurrence Relations.; Divide-and-Conquer as a Design Technique; Recursion – Recursive Data Types, Design of Recursive Functions / Procedures, Tail Recursion, Conversion of Recursive Functions to Iterative Form. Linear data structures – Lists, Access Restricted Lists (Stacks and Queues); Searching and Order Queries. Sorting – Sorting Algorithms (Online vs. Offline, Inmemory vs. External, In-space vs. Out-of-space, Quick Sort and Randomization), Lower Bound on Complexity of Sorting Algorithms. Unordered Collections: Hash tables (Separate Chaining vs. Open Addressing, Probing, Rehashing). Binary Trees – Tree Traversals. Partially Ordered Collections: Search Trees and Height Balanced Search Trees, Heaps, and Priority Queues. Probabilistic/Randomized Data Structures (such as Bloom Filters and Splay Trees). Generalized Trees – Traversals and Applications. Text Processing – Basic Algorithms and Data Structures (e.g. Tries, Huffman Coding, String search/pattern matching). External Memory Data Structures (B-Trees and variants). Graphs and Graph Algorithms: Representation

schemes, Problems on Directed Graphs (Reachability and Strong Connectivity, Traversals, Transitive Closure. Directed Acyclic Graphs - Topological Sorting), Problems on Weighted Graphs (Shortest Paths. Spanning Trees).

Equivalent: CS F211: Data Structures & Algorithms

MAC F243 Numerical Optimization 3 0 3

Review of Several Variable Calculus: Directional Derivatives, Gradient and Hessian, Taylor's theorem; Unconstrained optimization using calculus: minima and maxima, feasible directions, Convex functions, Coercive functions; Unconstrained optimization via iterative methods: Line search method, Newton's method, Gradient/conjugate gradient based methods, Quasi-Newton methods; Constrained optimization: Penalty methods, Lagrange multipliers, Karush-Kuhn-Tucker conditions, Quadratic programming; Linear programming (LP): Formulation of LP, Theorems dealing with vertices of feasible regions and optimality, Graphical solution; Simplex and revised simplex method, Duality theory.

Pre-requisites: MATH F112: Mathematics II

Note: Those who have done MATH F471 are not allowed to take this course.

MAC F244 Stochastic Calculus and Application to Finance 3 0 3

Overview of financial markets, derivative securities, discrete-time binomial model, arbitrage, hedging and replicating portfolios, risk-neutral probabilities and pricing formula, market completeness, concept of probability as measure, filtering, etc., stochastic processes, conditional expectation, martingales, Markov processes, Brownian motion and quadratic variation, Ito's integral and calculus, replicating portfolios and hedging in continuous time, Black-Scholes-Merton formulae, change of measure, Girsanov's theorem, risk-neutral pricing and existence of risk-neutral measure, market completeness and uniqueness of riskneutral measure, Markov property, Feynman-Kac theorem, local volatility and stochastic volatility models.

Pre-requisites: MATH F113: Probability and Statistics OR MATH F211: MATHEMATICS-III OR MATH F214: Elementary Real Analysis

MAC F245 Scientific Computing Laboratory 0 1 1

Introduction to MATLAB

Related to Numerical Analysis

Computational implementations of linear algebraic system: Gauss elimination, LU, Cholesky, QR decompositions; Iterative algorithms and their implementation; Least Square Method and SVD. Root finding algorithm; System of Nonlinear algebraic equations: one point iterative method and Newton's method; Piecewise Interpolations; Implementation of numerical quadrature's; Numerical implementations of ODEs.

Related to Numerical Optimization

Computational tools for optimization: Simplex algorithms, Newton's methods, Nonlinear optimization: Line search method, Newton's method, Gradient/conjugate gradient algorithms, Quasi-Newton methods, Penalty methods; Quadratic programming; Simplex and revised simplex methods.

MAC F311 Algebra I 3 0 3

Groups, subgroups, a counting principle, normal subgroups, and quotient groups, Cayley's theorem, automorphisms, permutation groups, Sylow's theorems, Rings, ring of real quaternions, ideals and quotient rings, homomorphisms, Euclidean rings, polynomial rings, and polynomials over the rational field.

Equivalent: MATH F215: Algebra I

MAC F312 Foundations of Data Science 3 0 3

Introduction to Data Science, Review of Probability, Random Variables and Probability Distributions, Bayesian probabilities, Conditional Gaussian distributions, Marginal Gaussian distributions, Bayes' theorem for Gaussian variables, Maximum likelihood and Bayesian Inference for the Gaussian, Mixtures of Gaussians, Probability Bounds, Nonparametric Methods – Kernel density estimators, Nearest-neighbour methods, Bayesian Curve Fitting, Introduction to constrained and unconstrained optimization, High

Dimensional Data & Curse of Dimensionality, Dimensionality Reduction, PCA & SVD, Data Visualization Techniques, OLAP and Multidimensional Data Analysis, Data Pre-processing, Big Data and Big Data Analytics, and Social Media data.

Equivalent: CS F320: Foundations of Data Science

MAC F313 Statistical Data Analysis 3 1 4

Graphical Representation of one- and two-dimensional data; simulation from common distributions including binomial, Poisson, normal, gamma exponential; inverse transform and acceptance-rejection method; goodness of fit tests; tests for independence; simple linear regression and least squares, MLE for regression, residual analysis; multiple linear regression, and variable selection; Generalized linear models, classification, logistic regression, LDA, QDA; Monte-Carlo simulation and integration; Bayes' theorem and Bayesian learning, Frequentist versus Bayesian and simple implementation.

Lab Component: Introduction to R programming and Implementations of algorithms discussed in this course.

Pre-requisites: MATH F113: Probability and Statistics

MAC F314 Mathematical Modelling 3 1 4

Review of ODEs: local existence, uniqueness results (without proof), Gronwall's inequality, continuation of solution (without proof), equilibrium points, linearised stability, phase-plane analysis and Liapunov stability (without proof); Mathematical Modelling: Principle of modelling, Dimensional analysis and scaling; Discrete Models: basic theory of difference equations (steady state, stability and critical parameters), Difference Equations applied to Biological models (Cell division and insect population, single population), two species interactions, Nicholson Baily model; Modeling through ODEs of first order: growth and decay models, compartment models; Modeling through systems of ODEs: bacterial growth in Chemostat, Glucose-Insulin Kinetics, Prey-Predator systems, SIR model, Hodgkin-Huxley nerve conduction model, Fitzhugh-Nagumo model of for Neural Impulses with analysis (limit cycle, oscillations); Modelling through PDEs: basics of modelling (conservation principles), diffusion based population dispersal model, Chemostatic motion of micro-organisms. **Lab**

Component: Group projects on Case Studies.

Equivalent: MATH F420: Mathematical Modeling

Pre-requisites: MATH F211: MATHEMATICS-III

MAC F341 Design and Analysis of Algorithms 3 0 3

Basic Design Techniques – Divide-and-Conquer, Greedy, Dynamic Programming (Examples, Analysis, General Structure of Solutions, Limitations and Applicability). Specialized Design Techniques: Network Flow, Randomization (Examples, Analysis, Limitations). Complexity Classes and Hardness of Problems – P, NP, Reductions, NP-hardness and NP-Completeness, Reduction Techniques, Basic NP-complete problems. Design Techniques for Hard Problems – Backtracking, Branch-and-Bound, and Approximation (General approaches and structure of solution, Analysis, and Limitations). Linear Programming – LP Problem and Simplex Algorithm, Approach for using LP for modeling and solving problems. Introduction to Design and Analysis of Parallel and Multi-threaded Algorithms.

Equivalent: CS F364: Design and Analysis of Algorithms

MAC F342 Computational Partial Differential Equations 3 1 4

Review of linear PDEs: First order linear scalar equation and explicit solution by characteristic method; Classification of 2nd order linear PDEs and maximum principle for Laplace and heat equations.

Finite differences: Grids, Finite-difference approximations to derivatives. Linear Transport Equation: Upwind, Lax-Wendroff and Lax-Friedrich schemes, von-Neumann stability analysis, CFL condition, Lax-Richtmyer equivalence theorem; Heat Equation: Initial and boundary value problems (Dirichlet and Neumann), Explicit and implicit methods (Backward Euler and Crank-Nicolson schemes) with consistency and stability, Discrete maximum principle, Convergence; Poisson's Equation: Finite difference scheme for boundary value problems, Discrete maximum principle, Iterative methods for linear systems (Jacobi, Gauss-Seidel,

SOR methods and Conjugate Gradient method), Peaceman-Rachford algorithm (ADI) for linear systems. Wave Equation: Explicit schemes and their stability analysis.

Lab Component: Implementation of algorithms discussed in this course

Equivalent: MATH F422: Numerical Methodology for Partial Differential Equations

MAC F411 Computation of Option Pricing Models 3 1 4

Review of financial market and options: arbitrage, options (European option, American option), interest rate and present value, random nature of stock markets and simple asset price model, Ito Lemma (without proof) and elimination of randomness; Basic Option theory: value of option, put-call parity; Black-Scholes PDE: European option, on dividend paying assets, American options, Hedging and implied volatility; Explicit Solution of Black-Scholes equation; American option as free boundary problem and formulation as variational inequality; Finite Difference methods for European options: Explicit Scheme with stability, convergence and probabilistic interpretation, implicit schemes (backward Euler, Crank-Nicolson scheme with stability and convergence; FDM for American options with projected SOR and convergence; pricing of Exotic options; Monte-Carlo for option valuation.

Lab Component: Implementation of European, American, and exotic options. Monte-Carlo Simulation.

MAC F266 Study Project 3

These courses include projects which are oriented towards readings from published literature or books about new frontiers of development or analysis of available database. These courses are normally available to students in second or higher levels. These courses must coterminate with project reports.

MAC F366 Laboratory Project 3

MAC F367 Laboratory Project 3

These courses include projects involving laboratory investigation or laboratory development in the students discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

MAC F376 Design Project 3

MAC F377 Design Project 3

These courses are intended to impart training in design of product/ process or other artifact to the students in the discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

MAC F491 Special Project 3

This is an unstructured open-ended course where under the overall supervision of an instructor-in-charge, batches of students will be attached to different instructors. Each batch will work on a specific time-bound project which is of basic or peripheral concern of his discipline. Each student must submit a project report as a culmination of his endeavour and investigation. The instructor-in-charge will determine the choice of the project and also whether or not the project report is to be submitted jointly by a group or individually by a student. The course will aim to evaluate student's actual ability to use the fundamentals of knowledge and to meet new unknown situations as demonstrated by the students' interaction with the instructors and instructor-in-charge and aggregated in the project report. The instructor-in-charge may assign specific hours for formal brain-storming sessions.

Mathematics

MATH F111 Mathematics I 3 0 3

Functions and graphs; limit and continuity; applications of derivative and integral. Conics; polar coordinates; convergence of sequences and series. Maclaurin and Taylor series. Partial derivatives. Vector calculus in R^n ; vector analysis; theorems of Green, Gauss and Stokes.

MATH F112 Mathematics II	3 0 3	MATH F231 Number Theory	3 0 3
Complex numbers, analytic functions, Cauchy's theorems; elementary functions; series expansions; calculus of residues and applications.		Primes and factorization; division algorithm; congruences and modular arithmetic; Chinese remainder theorem Euler phi-function and primitive roots of unity; Gauss's quadratic reciprocity law; applications to periodic decimals and periodic continued fractions.	
Vector space; basis and dimension; linear transformation; range and kernel of a linear transformation; row reduction method and its application to linear system of equations.		MATH F241 Mathematical Methods	3 0 3
MATH F113 Probability & Statistics	3 0 3	Integral Transforms: Fourier, Fourier sine/cosine and their inverse transforms (properties, convolution theorem and application to solve differential equation), Discrete Fourier Series, Fast Fourier transform, Calculus of Variation: Introduction, Variational problem with functionals containing first order derivatives and Euler equations, Variational problem with moving boundaries. Integral equations: Classification of integral equations, Volterra equations, Fredholm equations, Greens functions.	
Probability spaces; conditional probability and independence; random variables and probability distributions; marginal and conditional distributions; independent random variables; mathematical expectation; mean and variance; binomial, Poisson and normal distributions; sum of independent random variables; law of large numbers; central limit theorem (without proof); sampling distribution and test for mean using normal and student's t-distribution; test of hypothesis; correlation and linear regression.		MATH F242 Operations Research	3 0 3
MATH F114 Mathematics for Business	3 0 3	Introduction to Data Processing; Files and File Structures; Indexing Techniques; Sorting, Searching and Merging Techniques; Introduction to Database Management Systems; Design of Information Systems; Emerging trends in Data Processing.	
Ratios and Proportions, Simple and Compound interest, Percentage, Bill Discounting, Mathematical reasoning with basic application, Algebra, Set Theory and application of Venn Diagram, Variation, Indices, Logarithms, Permutation and Combinations, Simultaneous Equation models with business applications, Quadratic Equations and applications, Determinants and Matrices, Calculus with Business applications, Constant and variables, Functions, Limit and Continuity, Differentiation, Partial Differentiation and business applications, Derivatives, Maxima and Minima in the context of business studies, Indefinite Integrals, Definite Integrals, Index Numbers		MATH F243 Graphs and Networks	3 0 3
MATH F211 Mathematics III	3 0 3	Basic concepts of graphs and digraphs behind electrical communication and other networks behind social, economic and empirical structures; connectivity, reachability and vulnerability; trees, tournaments and matroids; planarity; routing and matching problems; representations; various algorithms; applications.	
Eigen-values and eigen-vectors. Inner product space and orthonormal bases. Elementary differential equations, Hypergeometric equations, Legendre polynomials, Bessel functions; Fourier series; Sturm-Liouville problem, series solution for differential equation, systems of first order equations; Laplace transformation and application to differential equations; one dimensional wave equation, one dimensional heat equation & Laplace equation in rectangular form.		MATH F244 Measure and Integration	3 0 3
MATH F212 Optimization	3 0 3	Lebesgue measure and integration in real numbers, Convergence and Convergence theorems, absolutely continuous functions, differentiability and integrability, theory of square integrable functions, and abstract spaces.	
Introduction to optimization; linear programming; simplex methods; duality and sensitivity analysis; transportation model and its variants; integer linear programming nonlinear programming; multi-objective optimization; evolutionary computation techniques.		MATH F266 Study Project	3
MATH F213 Discrete Mathematics	3 0 3	These courses include projects which are oriented towards readings from published literature or books about new frontiers of development or analysis of available database. These courses are normally available to students in second or higher levels. These courses must coterminate with project reports.	
Set theory: Sets, relations and functions, equivalence relations, partially ordered sets, countability of sets, lattices and Boolean algebras; Logic and Methods of Proof: Propositional logic, language of propositional logic, predicate logic and logical inference with quantifiers, introduction to different standard proof techniques; Combinatorics: Counting techniques: pigeon hole principle, inclusion-exclusion principle, recurrence relation, and generating function, partitions, special numbers like Fibonacci, Stirling, and Catalan numbers (Just an introduction). Graph Theory: Graphs and digraphs, special types of graphs, trees, isomorphism, connectedness, Euler and Hamilton graphs, planar graphs, Graph Laplacian; graph colouring.		MATH F311 Introduction to Topology	3 0 3
MATH F214 Elementary Real Analysis	3 0 3	Metric Spaces; Topological Spaces – subspaces, Continuity and homeomorphism, Quotient spaces and product spaces; separation Axioms; Urysohn's Lemma and Tietze extension Theorem; Connectedness; Compactness, Tychonoff's Theorem, Locally Compact Spaces; Homotopy and the fundamental group.	
Countability and uncountability of sets; real numbers; limits and continuity; compactness and connectedness in a metric space; Riemann integration; uniform convergence.		MATH F312 Ordinary Differential Equations	3 0 3
MATH F215 Algebra I	3 0 3	Existence and uniqueness theorems; properties of linear systems; behaviour of solutions of nth order equations; asymptotic behaviour of linear systems; stability of linear and weakly nonlinear systems; conditions for boundedness and the number of zeros of the nontrivial solutions of second order equations; stability by Liapunov's direct method; autonomous and nonautonomous systems.	
Groups, subgroups, a counting principle, normal subgroups and quotient groups, Cayley's theorem, automorphisms, permutation groups, and Sylow's theorems.		MATH F313 Numerical Analysis	3 0 3
Rings, ring of real quaternions, ideals and quotient rings, homomorphisms, Euclidean rings, polynomial rings, and polynomials over the rational field.		Principles of floating point computations and rounding errors; Systems of Linear Equations: factorization methods, pivoting and scaling, residual error correction method; Iterative methods: Jacobi, Gauss-Seidel methods with convergence analysis; Eigenvalue problems: algorithms with implementation issues; Nonlinear algebraic equation: root finding (bisection, secant, fixed point iteration and Newton-Raphson methods), nonlinear algebraic system (Fixed point iteration, Newton and Newton like methods); Interpolation: Lagrange interpolation techniques, piecewise linear and cubic splines, error estimates; Approximation: uniform approximation by polynomials, data fitting and least squares approximation; Numerical Integration: integration by interpolation, adaptive quadratures and Gauss methods; Initial Value Problems for Ordinary Differential Equations: Euler's method, single step Runge-Kutta methods, multi-step methods, predictor and corrector scheme, stability and convergence analysis. FDM for Two point BVP.	

MATH F314 Algebra II	3 0 3	MATH F353 Statistical Inference and Applications	3 0 3
Dual spaces, modules, fields, finite fields, extension of fields: algebraic extension, separable and inseparable extension, normal extension, splitting fields, Galois extension, and Galois group.		Review of elements of probability and statistical methods, Classical Decision theory including parametric and non-parametric methods for testing of hypotheses, Analysis of Variance: One way and two way classifications, Design of experiments: Analysis of Completely randomized design, Randomized block design and Latin square design with one or more missing values, Statistical Quality control for variables and measurements.	
The algebra of linear transformations, characteristic roots and characteristic vectors, canonical forms: triangular form, nilpotent form, and Jordan form.		MATH F354 Complex Analysis	3 0 3
MATH F315 Introduction to Statistical Inference	3 0 3	A rigorous treatment of the theory of analytic functions of complex variables including Cauchy's theorems; maximum modulus theorem; the principles of argument; Jensen's formula; Mittag Leffler theorem; Weierstrass canonical products and analytic continuation.	
Parametric point estimation; Unbiasedness; Consistency; Uniform minimum variance unbiased estimator; Method of moments; Maximum likelihood estimation and its properties; Lower bounds for the variance of an estimator; Sufficiency; Factorization theorem; Best equivariant estimators; Tests of hypotheses; Neyman-Pearson lemma; uniformly most powerful (UMP) tests; Likelihood ratio tests; Chi-square tests; Methods for finding confidence intervals.		MATH F366 Lab Project	3
MATH F316 Matrix Theory and Linear Estimation	3 1 4	MATH F367 Lab Project	3
Revision of linear algebra and allied concepts; Generalized inverse; Singular value decomposition their applications; Majorization, Principal components, Canonical correlations; Generalized inverses, Linear model, Estimability; Residual sum of squares; Schur complements, Multivariate normal distribution, quadratic forms and Cochran's theorem; One-way and two-way classifications, general linear hypothesis, Multiple correlation and regression models; Block designs and optimality: reduced form of normal equations, c-Matrix.		These courses include projects involving laboratory investigation or laboratory development in the students discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.	
MATH F317 Sampling Theory	3 1 4	MATH F376 Design Project	3
Advantages of the sampling method; Principal steps in a sample survey; Role of sampling theory; Probability sampling; Bias and its effects. Simple random sample: definitions and notation; Properties of the estimates; Variances of the estimates; Finite population correction; Estimation of the standard error from a sample; Confidence limits; Validity of the normal approximation; Effect of non-normality on the estimated variance. Sampling for proportions and percentages. Stratified sampling: Estimation of gain due to stratification; Ratio and regression methods of estimation; Unbiased ratio type estimators; Optimality of ratio estimate. Cluster sampling, Two stage sampling, Double sampling.		MATH F377 Design Project	3
MATH F341 Introduction to Functional Analysis	3 0 3	These courses are intended to impart training in design of product/ process or other artifact to the students in the discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.	
Banach spaces; fundamental theorems of functional analysis; Hilbert space; elementary operator theory; spectral theory for self-adjoint operators.		MATH F378 Advanced Probability Theory	3 0 3
MATH F342 Differential Geometry	3 0 3	Measure theoretic probability and probability space, Law of large numbers and independence, convergence, Central limit theorems, Higher dimensional limit theorems, Random walks and their properties, Martingale and their properties, Martingale convergence theorem, Radon-Nikodym derivative, Doob's inequality, Backward martingales, Markov chain and their properties, finite state ergodicity, recurrence and transience.	
Curve in the plane and 3D-space; Curvature of curves; Surfaces in 3D-space; First Fundamental form; Curvature of Surfaces; Gaussian and mean Curvatures; Theorema Egregium; Geodesics; Gauss-Bonnet Theorem.		MATH F420 Mathematical Modeling	3 1 4
MATH F343 Partial Differential Equations	3 0 3	Review of ODEs: local existence, uniqueness results (without proof), Gronwall's inequality, continuation of solution (without proof), equilibrium points, linearised stability, phase-plane analysis and Liapunov stability (without proof); Mathematical Modelling: Principle of modelling, Dimensional analysis and scaling; Discrete Models: basic theory of difference equations (steady state, stability and critical parameters), Difference Equations applied to Biological models (Cell division and insect population, single population), two species interactions, Nicholson Baily model; Modeling through ODEs of first-order: growth and decay models, compartment models; Modeling through systems of ODEs: bacterial growth in Chemostat, Glucose-Insulin Kinetics, Prey-Predator systems, SIR model, Hodgkin-Huxley nerve conduction model, Fitzhugh-Nagumo model of for Neural Impulses with analysis (limit cycle, oscillations); Modelling through PDEs: basics of modelling (conservation principles), diffusion based population dispersal model, Chemostatic motion of micro-organisms.	
Non linear equations of first order, Charpits Method, Method of Characteristics; Elliptic, parabolic and hyperbolic partial differential equations of order 2, maximum principle, Duhamels principle, Greens function, Laplace transform & fourier transform technique, solutions satisfying given conditions, partial differential equations in engineering & science.		Lab Component: Group projects on Case Studies.	
MATH F344 Mathematical Fluid Dynamics	3 0 3	MATH F421 Combinatorial Mathematics	3 0 3
Introduction to the Fluid Dynamics and Fundamental Concepts, Lagrange and Eulerian Descriptions, Continuum hypothesis, Conservation of Mass based on different approaches, Equation of Continuity in different Coordinates, Potential Flow, Laplace Equation, one-, two- and three-dimensional flow, Conservation of Linear Momentum, Euler's Equation, Bernoulli's equation, Constitutive equations for Newtonian Fluid, Navier-Stokes Equations, First Law of Thermodynamics, Reynolds number, Exact Solution of Navier-Stokes Equation, Boundary Layer Approximations, Setting up the Boundary-Layer Equations, Limit Equation For the Flat Plate, Discussion of Blasius' Equation, Description of Flow Past a Circular Cylinder, Decay of a Laminar Shear Layer.		Advanced theory of permutations and combinations; elementary counting functions; theory of partitions; theorems on choice including Ramsey's theorem; the mobius function; permutation groups; Polya's theorem and Debrauijn's generalisation; graphical enumeration problems.	
		MATH F422 Numerical Methodology for Partial Differential Equations	3 1 4
		Review of linear PDEs: First order linear scalar equation and explicit solution by characteristic method; Classification of 2nd order linear PDEs and maximum principle for Laplace and heat equations. Finite differences: Grids, Finite-difference approximations to	

derivatives. Linear Transport Equation: Upwind, Lax-Wendroff and Lax-Friedrich schemes, von-Neumann stability analysis, CFL condition, Lax-Richtmyer equivalence theorem ; . Heat Equation: Initial and boundary value problems (Dirichlet and Neumann), Explicit and implicit methods (Backward Euler and Crank-Nicolson schemes) with consistency and stability, Discrete maximum principle, Convergence ; Poisson's Equation: Finite difference scheme for boundary value problems, Discrete maximum principle, Iterative methods for linear systems (Jacobi, Gauss-Seidel, SOR methods and Conjugate Gradient method), Peaceman-Rachford algorithm (ADI) for linear systems. Wave Equation: Explicit schemes and their stability analysis.

Lab Component: Implementation of algorithms discussed in this course

MATH F423 Introduction to Algebraic Topology 3 0 3

Homotopy; Fundamental group and Computation; Covering Spaces; Universal Covering Spaces; Simplicial Complexes; Simplicial Homology and Computation.

MATH F424 Applied Stochastic Process 3 1 4

Definition and examples of Stochastic Processes (SPs), classification of random processes according to state space and parameter space, types of SPs, elementary problems; Stationary Process: Weakly stationary and strongly stationary processes, moving average and autoregressive processes; Martingales: definition and examples of martingales; Markov Chains: Transition probability, classification of states and chains, stability of Markov chains, irreducibility, stationary distribution ergodic theorem; Continuous-time Markov Chains (CTMCs): Poisson process, birth-death process and their applications; Continuous time and continuous state space: Brownian motion, Wiener process and applications; Renewal processes in discrete and continuous time; Renewal reward process; Branching Processes; Galton-Watson branching process and its properties.

MATH F425 Numerical Linear Algebra 3 1 4

Matrix algebra, conditioning, condition number, vector and matrix norms, perturbation theory of linear systems, stability of numerical algorithms, Cholesky decomposition, floating point arithmetic and its error analysis, singular value decomposition (SVD), algebraic and geometric properties of SVD, least square solutions, Moore Penrose inverse, Rank deficient least squares problems, Sensitivity analysis of SVD and least-squares problems, Householder matrices and transformation, QR method, Iterative methods with iterative refinement, Krylov subspace method, Arnoldi iteration, Low rank approximations.

Pre-requisite: MATH F112 Mathematics II

MATH F426 Mathematical Theory of Finite Element 3 1 4 Methods

Hilbert spaces, Sobolev Spaces, Variational formulation of elliptic boundary value problems, Lax-Milgram theorem, Error estimates, Construction of FE spaces, Polynomial approximations, interpolation errors, Aubin-Nitsche duality argument, Parabolic initial and boundary value problems: Semi-discrete and fully discrete schemes, error estimates.

MATH F427 Statistical Simulation and Data Analysis 3 1 4

Review of probability concepts; Pseudorandom number generation; Generating discrete random variables – Poisson and binomial random variables; Generating continuous random variables: Polar method for generating normal random variables; Discrete event simulation approach – single-server and two-servers queueing system, inventory model; Statistical analysis of simulated data – bootstrapping technique for estimating mean square errors; Several ways of variance reduction; Concepts of stratified sampling; Statistical goodness of fit tests – two sample problem; Markov chain Monte Carlo methods; The Hastings–Metropolis algorithm; Gibbs sampler; Continuous time Markov chains and a queueing loss model; Simulated annealing; Methods of data analysis.

MATH F428 Time Series Analysis and Forecasting 3 1 4

The course reviews Extrapolative and Decomposition Models, Introduction to Box–Jenkins Time Series Analysis, ARIMA Models,

which remains the most commonly used statistical technique in Time Series Analysis. The remainder of the course considers various practical aspects of the principles behind modern forecasting techniques. A one-hour lab will be conducted every week. Students will learn how to explore and analyze different types of Time Series data using R programming.

MATH F431 Distribution Theory 3 0 3

C-infinity functions, distributions and their derivatives; support, convolution and regularization; distributions of finite order; multiplication of distributions; Fourier transforms of distributions; temperate distributions and their Fourier transforms; fundamental solutions.

MATH F432 Applied Statistical Methods 3 0 3

Review of estimation and testing of hypotheses; Simple and multiple regression methodology through method of least squares, Multicollinearity and residual analysis, Categorical data handling through logistic regression; Multivariate data analysis by Hotelling T^2 , Mahalanobis D^2 , discriminant analysis, cluster analysis and factor analysis; Data handling and forecasting time series data by various components time series methodology; Statistical Quality Control of variables and attributes control charts; Non parametric data handling through Kruskal walls test, Mann Whitney and KS two sample test.

MATH F441 Discrete Mathematical Structures 3 0 3

One or more of the interrelated topics will be covered from the following: graphs, designs, codes, shift register sequences, groups, fields, Boolean algebras, analysis of algorithms, Fast Fourier Transform etc. providing a fertile ground for interaction between mathematics and modern areas of computer science. The selection of the topics will depend upon the circumstance and current interest of faculty.

MATH F444 Numerical Solutions of Ordinary Differential Equations 3 0 3

Introduction to ODEs, Numerical Techniques for One Step Methods, Convergence and Absolute Stability, Numerical techniques for Linear Multi-Step Methods, Zero Stability, Consistency, Convergence, Predictor-Corrector methods, Absolute Stability of Predictor-Corrector methods, Stiff ODEs and its numerical methods, Finite Difference Methods to Linear and Nonlinear Boundary Value Problems, Stability and Convergence Analysis, Differential Algebraic Equations, Numerical techniques for Differential Algebraic Equations, Introduction to One dimensional Finite Element Methods, Comparison between Finite Difference Methods and Finite Element Methods, Variational formulation, Finite Element Approximation, Approximation Errors, Convergence of solution, Order of Convergence.

MATH F445 Mathematical Fluid Dynamics 3 0 3

Introduction to the Fluid Dynamics and Fundamental Concepts, Lagrange and Eulerian Descriptions, Continuum hypothesis, Conservation of Mass based on different approaches, Equation of Continuity in different Coordinates, Potential Flow, Laplace Equation, one-, two- and three-dimensional flow, Conservation of Linear Momentum, Euler's Equation, Bernoulli's equation, Constitutive equations for Newtonian Fluid, Navier-Stokes Equations, First Law of Thermodynamics, Reynolds number, Exact Solution of Navier-Stokes Equation, Boundary Layer Approximations, Setting up the Boundary-Layer Equations, Limit Equation for the Flat Plate, Discussion of Blasius' Equation, Description of Flow Past a Circular Cylinder, Decay of a Laminar Shear Layer

MATH F456 Cosmology 3 0 3

History of cosmological ideas, Observational overview of the universe, Expansion of the universe, Newtonian gravity, Friedman equation, the fluid and acceleration equations, Geometry of the universe, Infinite and observable universe, Big bang, Simple cosmological models, Hubble law, redshift, Observational parameters, the cosmological constant, the age of the universe, weighing the universe, dark matter, CMB, the early universe, Nucleosynthesis, Inflationary universe, Initial singularity, standard cosmological model, general relativistic cosmology, classic cosmology, neutrino cosmology, baryogenesis, structure of the universe.

MATH F471 Nonlinear Optimization	3 0 3	MATH G515 Topics in Differential Equations	5
Introduction; convexity and cones; Kuhun Tucker theory; unconstrained and constrained optimization; gradient methods; polynomial optimization; penalty function; generalized convex functions; duality in nonlinear programming; optimality criterion for generalized convex functions; fractional programming.		The linear system of ordinary differential equations (ODEs), local existence and uniqueness theorems, stability of nonlinear ODE, Regular Sturm-Liouville Theory; method of characteristics for the first order hyperbolic partial differential equations (PDEs), classification of linear second order PDEs, Laplace equation, heat equation, wave equation, separation of variables, Fourier transform and application to heat and wave initial boundary value problems (IBVPs).	
MATH F481 Commutative Algebra	3 0 3	MATH G516 Topics in Topology	5
Modules; direct sums and products; finitely generated modules, exact sequences; tensor product of modules; rings and modules of fractions; localization; Noetherian modules and primary decompositions; integral dependence and valuation theory; integrally discrete valuation rings and Dedekind domains; fractional ideals.		Topological spaces and associated concepts, including box topology, product topology, connectedness, path connectedness, local compactness, limit and sequential compactness, para compactness, countability and separation axioms, metrizable, nets and filters, and fundamental groups. Arbitrary product of compact spaces through the Tychonoff's theorem.	
MATH F491 Special Projects	3	MATH G521 Applied Functional Analysis	5
This is an unstructured open-ended course where under the overall supervision of an instructor-in-charge, batches of students will be attached to different instructors. Each batch will work on a specific time-bound project which is of basic or peripheral concern of his discipline. Each student must submit a project report as a culmination of his endeavour and investigation. The instructor-in-charge will determine the choice of the project and also whether or not the project report is to be submitted jointly by a group or individually by a student. The course will aim to evaluate student's actual ability to use the fundamentals of knowledge and to meet new unknown situations as demonstrated by the students' interaction with the instructors and instructor-in-charge and aggregated in the project report. The instructor-in-charge may assign specific hours for formal brain-storming sessions.		MATH G531 Number Theory	5
		MATH G541 Advanced Methods in Discrete Mathematics	5
		Course description for the above courses are to be developed.	
MATH F492 Wavelet analysis and applications	3 1 4	MATH G611 Algebraic Number Theory	5
Haar wavelet bases, Multiresolution analysis, Orthonormal wavelets from MRA, Orthonormal spline wavelets, Fast wavelet transforms, Biorthogonal wavelet bases, Compactly supported wavelets, The Daubechies scaling functions, Coding signals by wavelet transform, Filter banks, Condition number of a matrix, Wavelet Galerkin method.		Localization, Galois extensions, Dedekind rings, discrete valuation rings; completion, unramified extensions, ramified extensions; the different and discriminant; cyclotomic fields, roots of unity, quadratic fields, relations in ideal classes; the unit theorem, Minkowski's constant, Zeta function.	
MATH G511 Design and Analysis of Algorithms	5	MATH G612 Riemann Surfaces	5
Design techniques such as divide-and-conquer, recursion, backtracking, branch-and-bound, simulation; Analysis in terms of average level and worst level efficiency; Relationship to appropriate data structures; Illustrations dealing with problems in computer science, graph theory and mathematics; Computational complexity and bounds; NP-hard and NP-complete problems.		Compact Riemann surfaces, algebraic functions, analytic continuations, branched coverings, study of line bundles, Riemann-Roch theorem, Serre duality theorem.	
MATH G512 Selected Topics in Advanced Mathematics 5 for Engineering Situations		MATH G621 Fibre Bundles	5
The topics may include mathematical theory of probability and stochastic processes, Graph theoretical techniques; information theory; pattern recognition; fuzzy sets.		Differential manifolds, tangent bundle, vector bundles, principal bundles, functorial properties, the Milnor construction, homotopy classification, Grassmannians, universal bundles, characteristic classes, introduction to K-theory.	
MATH G513 Topics in Algebra	5	MATH G622 Algebraic Geometry	5
Rings and Ideals, Fields, Field extension, Algebraic extension, Galois extension, Finite fields and applications, Introduction to Modules, Free modules, Finitely generated modules, Nakayama's lemma, Tensor product of modules, Direct limits, Alternating product, Flat modules, Absolutely flat rings, Projective modules, Finitely presented modules, Noetherian rings and modules, Hilbert basis theorem, Artinian Rings, Structure theorem for finitely generated modules over Principal Integral Domain (PID), Localisation of Rings and Modules.		Study of varieties, introduction to complex varieties, some ideas on schemes, complete varieties, cohomology of coherent sheaves.	
MATH G514 Topics in Analysis	5	MATH G632 Lie Groups and Lie Algebras	5
Some of the implications of completeness and compactness of metric spaces, including the Baire-category theorem and Arzela-Ascoli's theorem, Measure and integration on general measure spaces, Radon-Nykodym theorem, and its implications in probability theory, the fundamental theorem of Lebesgue integration, product spaces and Fubini's theorem, Fourier transform as a linear operator, Fourier inversion formula, Fourier-Plancherel theorem and their implications		Lie groups: basic definitions, one parameter sub-groups, maximal tori, representation theory; Lie algebras: basic definitions, solvable and nilpotent lie algebras, cartan subalgebras, roots and weights, simple lie algebras, classification theorem universal enveloping algebras, PBW theorem.	
		MATH G642 Complex Manifolds	5
		Manifolds and vector bundles: manifolds, vector bundles, & operator & almost complex manifolds; sheaf theory: Sheaf cohomology & Cech cohomology; differential geometry: Hermitian differential geometry, canonical connection & curvature of Hermitian holomorphic bundles, Chern classes of bundles.	
		Master of Business Administration	
		MBA G501 Managerial Economics	3 0 3
		The firm and it's environment, Introduction to basic principles & methodology, Revenue of the firm, Demand analysis & estimation, Economic forecasting; Production, cost and profit maximization, Production analysis, Cost of production, Profit analysis of the firm; Markets and behavior of the firm (Perfect competition, Monopoly, Monopolistic competition, oligopoly), Factor markets & profit maximizing employment of variable inputs, Games, information and strategy, pricing and profit analysis; Sectoral Economics.	

MBA G502 Business Structure & Processes 3*

Fundamental concepts, development of management theory, business forms, (proprietorship etc.); review of managerial functions (planning, organizing, staffing, leading and controlling); business processes, structure and systems, socio-economic interface.

MBA G503 Managerial Skills 2*

The role of manager, team building and goal setting, basics of supervision, leadership, decision making, negotiation skills and techniques, how managers communicate, how to interview, process of induction, training and development, delegation, how to appraise employees, how to manage time, use of committees, how to handle meetings, how to handle complaints.

MBA G504 Legal and Economic Environment of Business 4*

Indian contracts act, sale of goods act, negotiable instruments act, companies act, corporate tax laws, consumer protection and unfair trade practices act, FEMA, Industrial policy, macroeconomic environment, fiscal and monetary policy, overview of Indian economy, economic indicators.

MBA G505 Management Framework & Functions 2 0 2

Overview of management, its role and range of applications, building blocks and interrelations, core concepts, functional and strategic areas, quantitative tools and techniques, issues and approaches to problem solving, developing professional perceptions and attitudes.

MBA G506 Negotiation Skills and Techniques 2 0 2

Overview, Negotiation styles, Negotiation process, Tactics in Negotiation, Handling conflicts in negotiation, Best Alternative to a Negotiated Agreement, Communication - Key to Effective Negotiating, Non-verbal communication in Negotiations, Emotions: dealing with others and ourselves, International negotiations, Cross Cultural Issues in Negotiations, Power in negotiation, Workplace Negotiations, Turning Negotiation into a Corporate Capability, Do's and Don'ts of Negotiations, Negotiating over the telephone/ Electronic media, Ethics in negotiation, Negotiation-Exercise.

MBA G507 International Financial Markets & Services 3 0 3

Currency futures, options and swaps; interest rate determination and asset pricing in face of volatile nominal and real exchange rates; international portfolio management; treasury risk management and performance measurement; major international stock exchanges: New York; ISE London; Tokyo; trading and settlement practices; listing of Indian derivatives on Brussels stock exchange; arranging foreign collaboration; floating India funds; syndication of Euro-dollar loans.

MBA G508 Functions and Working of Stock Exchanges 3 0 3

Stock exchanges in India: regulations governing formation and working; trading and settlement procedures; review of the working of stock exchanges in India. National stock market system; OTCEI; listing requirements. requirements for membership of stock exchange; responsibilities of stock brokers in regard to contracts and accounts, duties and responsibilities to stock exchange, public and members interest; securities contracts act, by-laws and regulations; SEBI guidelines; trading in stock exchanges; insider trading: SEBI guidelines; dealings in debentures; rating of debentures; trading in government securities; potential for trading in derivatives.

MBA G509 Investment Banking and Financial Services 3 0 3

Merchant banking function- perspectives; organization of merchant banking function; managing new issues; negotiating terms with financial institutions, brokers, investors and under writers; pricing of further issues- SEBI guidelines; syndication of loans from banks; preparation of loan dossiers and application for financial assistance; negotiations; public deposits to finance working capital; agencies mobilizing public deposits; regulations governing raising of public deposits; cost of public deposits, factoring, forfeiting, structured finance, securitization and personal finance

like house loan, personal loan and other individual loans, non-fund based services -credit rating, business advisory services, mergers, de-mergers and acquisition, asset management and insurance commodities services and wealth management.

MBA G510 Human Resource Management 4

Introduction to Human Resource Management, Employment Laws, The Manager's Role in Strategic Human Resource Management, Job Analysis, HR Metrics, Human Resource Planning and Recruiting, Testing and Selection, Interviewing Candidates, Training and Developing Employees, Performance Management & Appraisal, Talent Management, Strategic Pay Plans, Pay for Performance and Employees Relations; Employee Relations & Employees safety & health; Managing Global Human Resource & HR in Entrepreneurial Firms; Futuristic trends in HRM; HRM in Indian Context.

MBA G511 Organisational Behaviour 4

Evolution and relevance; perception emotions and learning in an organisational set up; attitudes and values, groups and group processes, leadership, power and politics, organizational change, resistance and development, managing conflict.

MBA G512 Manufacturing Strategy 4

Corporate strategy; Missing links in manufacturing strategy; Audit approach; Restructuring; Manufacturing strategy process in practice; Formulation as a process; Operating strategies; Methodology framework; Lean production; Competitive priorities; Strategic value of response time and product variety; Flexibility in context of manufacturing strategy; Manufacturing focus; Business process reengineering; Theory of constraints; Link between strategy and organizational culture; Evolution of manufacturing systems; Operations management strategic perspective.

MBA G513 Quantitative Methods 4

Grouping data, measures of central tendency and dispersion, probability distribution, sampling and estimation, testing hypotheses, chi-square and analysis of variance, regression and correlation, non-parametric methods, time series and forecasting, index numbers, decision theory, linear programming, transportation and assignment problems, queuing theory, network problems, simulation; application of statistical software (SYSTAT, SPSS, SIMULA8, etc.) and spreadsheets.

MBA G514 Technology Management 3 0 3

Concept of technology, nature of technological change, economics of technology, corporate technology strategy, analysis for technology strategy, adoption and management of new technology, accounting for technology, appropriate technologies, transfer of technology, influence of government policies on technology, technology, management for sustainable development.

MBA G515 Financial and Management Accounting 4

Basic concepts, double entry accounting, journal, ledger, trial balance, profit & loss account, balance sheet, cash flow statement, financial statement analysis, ratio analysis, cost-volume-profit analysis, inventory valuation, inflation accounting, cost accounting and budgetary control systems, financial analysis and forecasting.

MBA G516 Corporate Finance and Taxation 4

Role and environment of managerial finance, time value of money (NPV, IRR), project feasibility, budgeting, long term investment decisions, long term financing decisions (LT & ST), capital structure, dividend decisions, short term financing decisions, working capital management, principles of corporate taxation, income tax, capital gains tax, tax laws and provisions, financial engineering.

MBA G517 Business and Society 4

Corporate social responsibility, business ethics, policies, codes, standards, ethics and decision making, environmental and social issues, workplace diversity, fostering ethics at work (whistle blower policy); business and social etiquette, internet and online behaviour, etiquette and office electronics.

MBA G518 Marketing	4	MBA G527 e-Business and Internet Marketing	4
Definition, marketing research and forecasting demand, creating customer value, satisfaction and loyalty, analysing consumer and business markets, market segmentation, brand equity, brand positioning, product and pricing strategies, managing services, managing value networks and channels, integrated marketing communications, international marketing.		e-business evolution & opportunities; categories of e-business; e-business models; network infrastructure & web based tools for e-business; e-business risks & risks management; network security and firewall; cryptography and authentication; billing/payment systems; regulatory environment of e-business; ERP/SCM/CRM and web based marketing; business intelligence & intelligent systems; data warehousing and data mining; implementing e-business systems & change management. Case studies and projects in e-business areas; emerging e-business scenarios.	
MBA G519 Production and Operations Management	4	MBA G528 Internet Security and Cyber Laws	4
Product & service design, plant location, aggregate planning, capacity, process, layout, sequencing & scheduling, line balancing, maintenance, quality (control, assurance, management), statistical quality control, queuing theory, project management. CPM, PERT.		Examination of issues related to network and information security, security concepts, security attacks and risks, security architectures, security policy management, security mechanisms, cryptography algorithms, security standards, security system interoperation and case studies of the current major security systems.	
MBA G520 Business Policy and Strategic Management	4	MBA G529 Recent Advances in ETM	4
Mission, vision, strategic intent, hierarchical levels of strategy, PEST analysis, SWOT analysis, industry analysis, organisational analysis, BCG matrix, GE matrix, core competencies, five force theory, value chain, competitive advantage, generic strategies, diversification, strategy implementation and control.		Course description is to be developed.	
MBA G521 Supply Chain Management	4	MBA G530 Project Appraisal	3 0 3
Purchase/procurement, stores, material handling systems, inventory analysis, inventory models, disposals, make or buy, outsourcing; vendor selection, development, and relations; Material requirements planning, manufacturing resources planning, ERP, JIT, inbound and outbound logistics, warehousing, transportation, packaging.		Criteria for selection of a project; factor intensity; commercial profitability; national economic-profitability; limitations of market prices; estimation of shadow prices; linkup project appraisal to national objectives; McGaughey and Thorbeck approach; Little-Mirrlees method; UNIDO guidelines approach; limitations of the conventional project appraisal; towards a new framework for project appraisal.	
MBA G522 Total Quality Management	4	MBA G531 Managerial Communication	2*
TQM principles and practices; leadership; customer satisfaction; employee involvement; continuous process improvement; supplier partnership; performance measures; statistical process control; ISO 9000; benchmarking; quality function deployment; concurrent engineering; experimental design; Taguchi's quality engineering; product liability.		Business communication basics; issue interpretation, reformulation and summation; interviews, questionnaires and forms; presentation techniques; technology and communication; business correspondence; business documents; group communication and meetings; employment communication.	
MBA G523 Project Management	4	MBA G532 Risk Management and Insurance	3 0 3
Concepts and techniques of project formulation, evaluation and implementation; Project planning and scheduling; Risk management; Time-cost trade off; Resource leveling and allocation; Project monitoring and control; Contract management.		Introduction to risk; types of risk; risk measurement; risk management techniques; risk avoidance, loss control, loss financing, risk retention, risk transfer, internal risk reduction through diversification etc.; insurance business and operations; insurance pricing; insurance v/s hedging; life, health and income risk; property and liability risk – commercial and personal; social insurance; insurance regulation.	
MBA G524 International Business	3 0 3	MBA G533 Advertising and Sales Promotion	3 0 3
Global Trade Protection, Cultural Environment, Legal Aspects, International Monetary System, Overseas Business Options, MNCs, Regional Analysis, Screening and Segmentation, International Marketing Research, International Marketing Strategy, Export Policy and Institutional Infrastructure, Export Finance, Export Payments, Exchange Transactions, Product Planning; Positioning and Management, Distribution Policy; Management and Agreements, International Pricing and Promotion, Organizing for Overseas Markets.		The communication process and models of persuasive communication; advertising research; advertising campaign components; advertising campaign planning; advertising/media scene; media concepts; media planning & strategy; advertising campaign planning, execution and evaluation; advertising agencies; sales promotion types and techniques; sales promotion strategy; measuring the effectiveness of the promotional program; regulations of advertising and promotion; Extending marketing communication to social communication, personal selling, international advertising, interactive advertising, advertising laws, social, ethical and moral issues.	
MBA G525 R&D Management	3 0 3	MBA G534 Introduction to Business Sustainability	3 0 3
Distinctive need and particular structure for management of R&D systems; the close relationship between R&D objectives and innovation and precise time targets; micro considerations like economics and cost, science policy, criteria of choice, various issues connected with availability, transfer and marketing of technology; micro considerations in planning, organisation, project selection, formulation and management, R&D cost estimating and budgeting human resources availability, evaluation and measurement of performance, control problems; mission-oriented research; technology missions enunciated by Indian Government.		Evolution of the Concept of sustainable development, Dimensions of sustainable development, Issues and Trends in business sustainability, Business Sustainability, Sustainable Consumption and Production, Industrial Environment Management, Finance of sustainability, Setting Goals and Measuring Progress towards sustainability	
MBA G526 Database Management Systems	4	MBA G535 Cross Cultural Management	3 0 3
Introduction to data bases and management; data files and structures; hierarchical, relational, network models; distributed data bases; query processing and query optimization, query languages; concepts of security and protection; case study of a data base system.		The Critical Role of Culture in Management, The Various Dimensions of Culture, The Impact of Culture On Management Functions Like Communication, Negotiation, Motivation, Leadership and Human Resource Management, Formulating and Implementing Strategy for International and Global Operations, Managing Global Teams, International Assignment and Expatriate Management, Skills and Competencies for Global Managers, International	

Business Etiquette and Uniqueness of Indian Culture and Management.

MBA G536 Strategic Financial Management 3 0 3

Company Value and the Manager's Mission: Introduction to Valuation, Why Value Value? The Value Manager, Cash Is King and Value-Based Management. Approach to Valuation - A Practitioner's Guide: Frameworks for Valuation. Valuation Methods: Discounted, Relative and Contingent Claim. Analyzing Historical Performance. Forecasting Performance. Estimation of Discount Rates. Estimation of Cash Flows. Estimation of Growth Rates. Valuation Models: Dividend-Discount Models, Free-Cash-Flow-To-Equity Discount Models, Free-Cash-Flow-to-firm Approach, Price / Earnings Ratio, Price/Book Value Ratio and Price/Sales Ratio. Measuring and Managing the Company Value: Company Value vs. Shareholders Wealth Maximization - TSR. Economic Value Added, Market Value Added and Cash Value Added. Wealth Creator by the Indian Corporates. Analyzing the Company Performance - Application of Balanced Scorecard (BSC). Applying Valuation: Multipbusiness Valuation. Mergers, Acquisition, and Joint Ventures.

MBA G537 Security Analysis and Portfolio Management 3 0 3

Introduction to investment and securities; profile of financial assets; new issue market or primary market, initial public offerings (IPO); secondary market; framework of risk & return; fundamental analysis- economy, industry; company analysis; stock evaluation models; multiple holding period and multiple growth rate; bond analysis and bond management strategies; technical analysis; efficient market theory; portfolio management; Markowitz model; Sharpe's Single Index model; capital asset pricing model; financial derivatives-options & futures.

MBA G538 Marketing Models 3 0 3

Introduction to Marketing Models, Understanding the consumer behavior models, Developing models for optimal pricing decisions, Product definitions and classifications, Modeling the effects of Advertising, media selection and scheduling, Understanding Distribution problem, strategy, location, Learning New Product Planning, Innovation Diffusion process, Understanding Marketing planning Strategy Decision, Decision and Implementation.

MBA G539 Six Sigma 3 1 4

Voice of business/customer, Basic concepts of quality management, Quality function deployment, Developing Six sigma project charter, Measurement system analysis, Gauge repeatability and reproducibility, (R & R), Measuring base line performance, sigma short term, sigma long-term, sigma goal and entitlement, Validating the measurement systems, Cause-effect(CE) diagrams, charts hypothesis testing, Pugh matrix, Design of experiments, Design of Experiments, Analysis of Variance (ANOVA), Evolutionary Operation (EVOP); Fractional, Full and Orthogonal Experiments, Regression model building, Taguchi methods for robust design, Six Sigma sustainability, Process capability analysis, Process Capability (Cp), Process Capability Index (Cpk), Process Performance (Pp), Process Performance Index (Ppk), Combing the power of lean and six sigma.

MBA G540 Sports Marketing 3 0 3

Understanding scope of sport marketing, Strategic sport marketing planning process, Sport consumer decision making process, Carrying out research in sport, Strategic pricing process in sport, Facility planning and marketing channels for sporting goods and services, Understanding market segmentation from viewpoint of customer and player, Branding and promotion decisions, Tactics for higher sponsorships, Licensing venue and event marketing, Advertising strategy in sports, Global sports marketing, and Public relations in sports.

MBA G541 Operations Strategy 3 0 3

Operations Strategy, Operations Performance, Capacity Strategy, Purchasing and Supply Strategy, Process Technology Strategy, Improvement Strategy, Product and Service Development and Organization, Process of Operations

Strategy-formulation, implementation, Monitoring and Control etc.

MBA G542 Consumer Behaviour 3 0 3

Concepts and characteristics of modern consumer behaviour; marketers' and consumers' views of consumer behaviour; market segmentation of consumers; consumer motivation; personality, values and involvement; consumers' perception, learning and attitudes, external influences on consumer behaviour-social, cultural, and situational; influences of sales persons and advertising on consumer behaviour; consumer decision process.

MBA G543 Leading Modern Organizations 3 0 3

Evolving role of management in organizations and functional areas, Importance of leadership in modern day organizations, Various models and theories of leadership, Understanding leadership from four perspectives : Self-assessment of Individual Leadership through models of personal growth and effectiveness; Team Leadership: importance of motivation, building trust, managing crisis and communicating effectively for creating high performing teams: Organizational Leadership: Inspiring innovation and change, enabling changes effectively, ethical leadership and; understanding the situational factors of effective leadership in the Global Context, Ethical Leadership.

MBA G544 Organizational Theory & Behaviour 3 0 3

Organizational Behaviour; Diversity in Organizations, Attitude and Job Satisfaction, Emotions and Moods, Personality & Values, Perception and individual Decision Making, Basic Motivation: Concepts & Applications, Foundations of group behavior & Understanding work teams, Organizational communication, Transactional analysis and Managerial Interpersonal Relations, Power and politics, Conflict management.

Organizational Structure, Organizational Design, Organizational culture, Organizational change, Positive organizational behavior, Ethics in organization.

MBA G545 Management Science 3 0 3

Management Science Approach to Problem Solving, Model Formulation and Graphical Solution, Computer Solution and Sensitivity Analysis, Modelling and Applications, The Simplex Method, Transportation Problem and its variants; Assignment Problem and its variants, Integer Programming and its Location; Goal Programming (GP); Loading and Machine scheduling; Distribution Problems; Waiting Lines and Queuing Theory Models, Simulation Modeling; Applications in Workforce Planning, Marketing, Investment, Healthcare Systems, Education and other business cases and applications.

MBA G546 Business Statistics 3 0 3

Randomness and Probability; Random Variables and Probability Models; Theoretical Probability Distributions; Sampling and Sampling Distributions; Estimation; Testing of Hypothesis in Case of Large and Small Samples; Chi – Square Test; F – Distribution and Analysis of Variance (ANOVA); Regression Analysis; Time Series Analysis; Index Numbers, Business Case Problems and applications.

MBA G547 Accounting for Managers 3 0 3

Basics of accounting concepts and practices, collecting, recording and reporting accounting information: journal entries, ledger and trial balance, preparation of final accounts, financial statement analysis — ratio analysis, Indian Accounting Standards, taxation – direct, indirect and GST etc. and their implications on financial reporting, management accounting tools and techniques: introduction to cost concepts, understanding the nature and importance of various cost components, introduction to various control systems in an organization: preparation & analysis of budget as a tool for management control system, preparation of cost sheet and standard costing. Ethical Issues in Corporate governance.

MBA G548 Strategic Marketing 3 0 3

Viewing marketing as a value creation process, Using a framework to analyze market opportunities Analysis, Situational Analysis, Understanding the buying-decision process of consumers,

Selecting the target market and positioning the product, Developing an integrated marketing program, Designing products and services that deliver meaningful customer value, Using the "augmented" product as an antidote to commoditization, Capturing created value for the firm, Shifting from cost-based to value-based pricing, Planning the budget and media mix for marketing communications, Designing and managing the distribution channel, Positioning the internet as an effective online sales tool, Redefining strategy for the digital world, Understanding how digital and social media marketing contribute to a sustainable business strategy, Creating a strategic marketing plan, Anticipating and adapting to change, Ethical issues in marketing.

MBA G549 Introduction to Systems & Sustainability 3 0 3

Introduction to system, Open and closed system, Socio-ecological system, Systems for Sustainability, Sustainable development – evolution, approaches, interpretations, Climate change – Law policy & opportunities, Business (corporate) sustainability, triple bottom line, CSR, Social Accounting, Social Investment, Impact Assessment, Sustainability and Profitability, Sustainable production and consumption, zero emission in industries, Sustainability benchmarking and indicators, Sustainability reporting.

MBA G550 Critical and Design Thinking 3 0 3

Learning about thinking, deductive, inductive and abductive thinking, Convergent and Divergent thinking, Lateral thinking, Adversarial thinking, Parallel thinking; Creativity and Innovation, Problem definition, Theory of Constraints, 5 Why's method, Principles of Design Thinking, enabling design thinking in teams, application of design thinking; Systems principle, Holistic thinking, Learning Organization, Integrative thinking.

MBA G551 Internetworking Technologies 3 0 3

Introduction to internetworking concepts; the internet architecture; goals and key issues related to internetworking technologies; design aspects; HTTP and other relevant protocols; agent technology and tools relevant to the internet; techniques of data compression; voice, video, and interactive video-on-demand over the internet; multimedia operating systems and their impact; multimedia networking; mobile computing; internet security; case studies.

MBA G552 Total Productive Maintenance 4

Outline of TPM; TPM – Challenging limits; Maximizing equipment effectiveness; Organizing for TPM implementation; TPM implementation and stabilization; TPM small group activities; the PM prize for outstanding TPM plants.

MBA G553 Organizational Change and Development 3 0 3

Business Organisation: The Domain of Change; Concept of Change; Perspectives on Organizational Change; Models of Change; Organizational Resistance to Change; Organizational Change and Change Agents; Strategic Management of Change; Organizational Diagnosis; Organizational Development (OD); Organizational Transformation (OT); Role of Change Agents and Leadership; Manager as Catalyst of Change; Implementing Organizational Change; Organizational Culture and Change; Learning Organization: The Ultimate Objective of Change Management.

MBA G554 Innovative Leadership 3 0 3

Leadership for innovation, Stimulating Bottom-Up innovation, Steering innovation Top-down, Appointing an Innovation Conductor, Leadership Imperative for Innovation Strategy, Leading development of new products, Leading the creation of totally new product/service, Innovation leaders as pragmatic architect, Leading improved customer solutions, Building an innovative leadership environment, Attracting, developing and keeping Innovative Leaders.

MBA G555 International Human Resource Management 3 0 3

Enduring context of International Human Resource Management (IHRM), Context of Cross-border Alliances and SMEs, Staffing International Operations for Sustained Global Growth, Recruiting and Selecting Staff for International Assignments, International Training and Development, International Compensation, Re-entry

and Career Issues (Expatriation Issues), IHRM in the Host Country Context, International Industrial Relations, Performance Management, IHRM Trends: Complexity, Challenges and Choices in the Future.

MBA G556 Performance Management 3 0 3

Overview of Performance Appraisal & Management, Performance Management in the Organizational Context, systems & processes; Goal Setting, Approaches to Performance Appraisal, Performance Appraisal Techniques, Data Gathering, Observing, and Documenting, The Performance Appraisal Meeting, Feedback, Performance Diagnosis and Improvement, Linkage to Rewards & Compensation, Training & Development Requirements, Potential Appraisal & Career Progression, issues: Problems, Role of HR, Training the appraisers, Performance Appraisal in India.

MBA G557 Economic Environment of Business 3 0 3

Introduction to Business Environment, Role of Government in policy formulation, Mercantile laws: Indian Contract Act 1872, Indian Sales of Goods Act 1930, Macro Economic Concepts: Consumption, Savings, Investment, Economic Growth, Industrial policy, Introduction to the financial markets, Money supply and Banking system, National Income, Implications of Fiscal policy and Monetary policy for Business.

MBA G558 Operations and Supply Chain Management 3 0 3

Strategic importance of Operations, Forecasting, Product planning, Management of Quality, Statistical Process Control, Process Strategy, Layout planning, Production Scheduling, Inventory Management, MRP, Supply chain Management: An Overview, Supply chain strategy, Supply chain performance measurement, Distribution networks, Order management and customer service, Sales and Operations Planning, Transportation, Digital Supply chain, IoT and Blockchain, Sustainability in Supply chain, Ethical supply chain.

MBA G559 Corporate Finance 3 0 3

Basics of financial management, time value of money, valuation of securities, risk return and opportunity cost of capital, capital budgeting, WACC and company valuation, capital financing decisions – capital structure, working capital management, dividend decisions, Aspects of Mergers & Acquisitions, Risk Management, International Financing. Ethical versus legal standards in finance, Limited Liability, its Effects and Legal Responses, Insider Dealing and Market Abuse, Regulatory Competition and Regulatory Arbitrage.

MBA G560 Marketing Research & Metrics 3 0 3

Elements of marketing research process viz. Problem Definition, Development of an approach to the Problem, Research Design formulation, Exploratory, Descriptive and experimental, Fieldwork & Data collection, Data preparation & Analysis, univariate, bivariate and multivariate statistical techniques, Report preparation and Presentation. Marketing metrics. Nonfinancial metrics: Brand awareness, Test drive, Churn, Customer satisfaction (CSAT) and Take rate; Financial metrics: Profit, Net present value (NPV), Internal rate of return (IRR), Payback, Customer lifetime value (CLTV), Cost per click (CPC), Transaction conversion rate (TCR), Return on ad dollars spent (ROA), Bounce Rate and Word of mouth (WOM).

MBA G561 Business Analytics 3 0 3

Decision Making using Business Analytics; Business Analytics in Practice; Advanced Data Visualization; Data Dashboards, Predictive and Prescriptive Spreadsheet Models; Cluster Analysis; Text Mining; Logistic Regression; k-Nearest Neighbors; Classification and Regression Trees; Building Good Spreadsheet Models: What-If Analysis; Auditing Spreadsheet Models; Risk Analysis; Simulation Modelling; Application of optimization models: Capital Budgeting; Bank Location; Product Design and Market Share Optimization; A Location Problem; Markowitz Portfolio Model; Forecasting Adoption of a New Product; Big Data: Statistical Inference and Practical Significance; Case Problems, Data Governance & Ethics.

MBA G562 Services Marketing	3 0 3	MBA G571 Management Information Systems	3 0 3
Distinctive elements, system: relationships with customers; positioning; managing customer portfolio, demand management, service delivery process, pricing; promotion; operating strategy; quality, productivity, human resource management; internationalization of services; services marketing in future.		Introduction to Information Systems; Concepts of management, concepts of information, systems concepts; Information Systems and Organizations; decision making process; database systems; data communications; planning, designing, developing and implementing information systems; quality assurance and evaluation of information systems; future developments and their organizational and social implications; decision support system and expert systems.	
MBA G563 Industrial Marketing	3 0 3	MBA G574 Retail Management Systems	3 0 3
Market/consumer orientation, marketing in industrial context, industrial market behaviour, organisational buying and buying behaviour, business forecasting and planning, product planning, new product development, pricing, distribution, management of communications, advertising & personal selling, management of sales force, corporate strategy and industrial marketing.		Retailing history and theories, basic retail management process, retail industry in Indian and abroad, shopper behavior in retailing, retailing formats and location related issues, category management, supply chain management in retail, retail buying, store layout and design, point of purchase communication, retail pricing strategy, building store loyalty and technology in retailing. Case studies and projects in retailing, specially focusing on Indian scenarios.	
MBA G564 Decision Making	3 0 3	MBA G575 Financial Engineering	3 0 3
Decision Analysis, Decisions under certainty and under uncertainty, Behavioral Decision Making, Framing of Decisions and Psychology of Choice, Common Errors, Paradoxes, Anomalies and Traps, Game theory- simple, two - player and bi- matrix games, Concepts of dominance, equilibrium and iterated dominance, Negotiation Analysis, Joint and Collaborative Decisions.		Introduction; Review of Markets, Players, and Conventions; Cash Flow Engineering with Forward Contracts; Engineering Simple Interest Rate Derivatives; Swap Engineering; Report Market Strategies; Dynamic Replication Methods and Synthetics; Mechanics of Options; Options Engineering with Applications; Pricing Tools; Applications of Fundamental Theorem of Finance; Fixed Income Engineering; Tools for Volatility Engineering: Volatility Swaps and Volatility Trading; Engineering of Equity Instruments: Pricing and Replication, computational methods such as Monte Carlo Simulation.	
MBA G565 Information & Knowledge Management Systems	3 0 3	MBA G576 Digital Marketing	3 0 3
Information systems, organization and strategy; Ethical and social issues in information systems; IT infrastructure, emerging technologies, tools and portals for information and knowledge management; Creating, accumulating and applying knowledge in a learning organization; Building information systems in a learning organization; Information and knowledge management systems in digital economy; Managing projects; Future of information and knowledge management systems in the modern era of business.		Fundamentals of e-Business and Internet Marketing, e-Business Models and Frameworks, Digital Marketing Strategy, Online Public Relations, Search Engine Optimization and Marketing, Content Marketing, E-Mail Marketing, Social Media Marketing, Mobile Marketing, Optimizing Customer and User Experience, Web Analytics.	
MBA G566 Strategic Management	3 0 3	MBA G577 Supply Chain Analytics	3 1 4
Overview of strategy, Crafting Strategy, company's strategy and its business model; Environmental Scanning, General Environment, Task Environment, STEEP analysis, Industry analysis; Resource based view of firm, Core competence, Distinctive competence, Competitive Advantage, Sustainable competitive advantage, Value Chain analysis; Strategy Formulation; Corporate strategy, business strategy, functional strategy; Strategy Implementation; Strategy Evaluation; Advanced Topics of strategic management: Blue Ocean Strategy, Ethical Issues and conduct.		Introduction to supply chain analytics, Data understanding and data preparation, Supply chain performance, Descriptive analytics, Predictive analytics and setting up the problem, Supply chain forecasting, studying holt, winter and ARIMA models, Supply chain Network Planning, Multi echelon network optimization, Supply chain sales and operations planning, Supply chain segmentation, Vehicle routing problems, Supervised and Unsupervised learning, Use of Bayesian networks in supply chain, Simulation and SC models, Supply chain risk management.	
MBA G567 Technology Innovation & Entrepreneurship	3 0 3	MBA G578 Game Theory and Business Strategy	3 0 3
Technology & Innovation; Role of technology & entrepreneurship in addressing societal needs/problems, creation of economic activities and wealth; Understanding Technology innovation cycle; Timing factor; Technology-price relationship; Understanding of technology life cycle; Technology planning & Roadmap; Types of innovation; Disruptive innovation and innovation for base of the pyramid; Process and key elements of entrepreneurship: Entrepreneurial opportunity recognition and feasibility analysis; Developing B-Plan; innovating Business Model, Legal Aspects and financing.		Psychology and philosophy of games of strategy; Non-cooperative, One-time, Static Games with Complete Information; Finitely, Infinitely Repeated, Static Games with Complete Information; Mixed Pure Strategies; Games with imperfect competition; Games with perfect competition and monopoly; Strategic Trade Policy; Dynamic Games with Complete and Perfect Information; Bargaining; Pure Strategies with Uncertain Payoffs; Auctions.	
MBA G568 International Business Strategy & Operations	3 0 3	MBA G579 Management Practice	3*
Introduction to International Business, International Market, Cultural environment, Legal, political, economic and monetary aspects facing IB, Governments influence on trade via policies and instruments, Trade theory, Global Trade Protection and the Institutional Background, Global foreign exchange markets, trading process and benefits to IB, Determination of exchange rates, forex arrangements, role of IMF, forecasting and IB benefits, IB Strategy for sustainable value creation and profitability, Multinational corporation, Types of global strategies: integration & responsiveness, Export and import strategies: global & Indian context, Export - Import Procedures, Country evaluation and selection, Marketing globally & use of digital technologies, Global supply chain management, theory of FDI, Multinational Finance function, India specific analysis: Export Incentives, assistance, ECGC, export finance, role of banks and other institutions, Emerging market enterprise strategies.		This course is intended to make student explore a business problem and offer insights for the solution using management frameworks, tools & methodology under the guidance of faculty member(s). This may include research work. The student will submit the report after completion.	
		MBA G581 Expert Systems	4
		The object of this course is to study in details the features of expert systems and their role in the scientific world of today and tomorrow. It concentrates on the tools available to the knowledge engineer, expert systems, building techniques, and the difficulties which may be encountered during the development of an expert system.	

MBA G582 Creating & Leading Entrepreneurial Organizations 3 0 3

Fundamentals of entrepreneurship; elements of leadership; identifying business opportunities; market study and research; business plans; finance, issues in raising finance; venture capitalist evaluation of business plans, technical aspects for the project, corporate strategies for growth; legal aspect to entrepreneurship, people skills, marketing and branding; creativity and communication.

MBA G583 Marketing Research 3 0 3

An examination of the concepts and practical methodology used in marketing research. An overview of marketing research process, with emphasis on research design; data instrument design; questionnaire formulation; sampling plans; data collection methods -interviewing, panels; data analysis and use of computer based information systems for marketing intelligence. Also Time-series & Regression based models of sales forecasting, control and evaluation of marketing function and survey methodology are covered.

Emphasis will be on cases and research projects.

MBA G586 Product and Brand Management 3 0 3

Scope of product Policy Decisions; Product-Market strategy; Product Life Cycle and Strategy; Managing Product Deletion; Product Associations; Branding including aspects of brand name selection; Brand Equity and its utilization for marketing decision making; Brand Extension: use for brand names for launching new products; New product development process; Idea Generation and Screening; Concept Development and Evaluation; Product Design and Testing; Market planning; Testing the market plan; Marketing research process; Adoption and Diffusion of products; Organizing for new and existing product.

MBA G588 Services Management System 3 0 3

Understanding Services, the Service Sector today, Designing the Service Enterprise, Technological Issues, Structuring Service Operations, Processes Management, Staffing for Services, Functions of Services Management System, Client Relationships, Measuring and Reporting Services.

MBA G589 Enterprise Resource Planning 3 0 3

Introduction to ERP; Re-engineering and ERP systems; ERP planning, design, and implementation; ERP systems – sales and marketing; ERP systems – accounting and finance; ERP systems – production and materials management; ERP systems – human resources; Managing and ERP project; Supply chain management and e-Market place.

MBA G593 Business Analysis and Valuation 3 0 3

Theory of finance, value maximization, stakeholder theory, and corporate objective function: value creation – ways and means, business analysis: The techniques of strategy and competitive analysis, value chain analysis for competitive advantages, business valuation – approaches and methods, the dark side of valuation: strategic investment decisions.

MBA G622 Software Project Management 4

Managing a software development project, concepts, objects of a project, environment of a software project, system development life cycle, tools, review process; documentation in software program management, procedures, diagramming techniques, management; Planning and monitoring a software project, project planning, management tools, software project definitions, project management packages, project control; software project definition, classification, project sizes and methodologies, feasibility, requirements and start-up; programmer productivity; software planning, control tools, accelerated design; prototyping and role in software project management; software production and software project management; software system installation, managing testing requirements, test plans, alpha and beta systems; emerging directions in project management.

MBA in Business Analytics

MPBA G501 Managerial Economics 3 0 3

The firm and its environment, Introduction to basic principles & methodology, Revenue of the firm, Demand analysis & estimation, Economic forecasting; Production, cost and profit maximization, Production analysis, Cost of production, Profit analysis of the firm; Markets and behavior of the firm (Perfect competition, Monopoly, Monopolistic competition, oligopoly), Factor markets & profit maximizing employment of variable inputs, Games, information and strategy, pricing and profit analysis; Sectoral Economics.

Equivalent: MBA G501

MPBA G502 Financial Statement Analysis & Reporting 3*

Financial Statement Analysis and reporting depicts the financial health of any company and helps the companies to augment their financial resources and management of generated funds efficiently. The course provides an overview of the preparation of financial statements and understanding, financial analysis of statements, and the significance of financial reporting.

MPBA G503 Marketing Management 3 0 3

Definition, marketing research and forecasting demand, creating customer value, satisfaction and loyalty, analysing consumer and business markets, market segmentation, brand equity, brand positioning, product and pricing strategies, managing services, managing value networks and channels, integrated marketing communications, international marketing.

MPBA G504 Managing People & Organization 3 0 3

Fundamental concepts and principles of management as applied to a variety of organizations; elementary study of managerial roles, styles, activities and decision making; relationship with organizational effectiveness; basic concepts relating to planning activities, manpower development; basic concepts relating to organizational behaviour.

MPBA G505 Statistics & Basic Econometrics 3*

Probability and Probability Distributions, Characteristics of Probability Distributions, Some Important Probability Distributions, statistical inference, estimation and hypothesis testing; ANOVA, MANOVA, MANCOVA, the linear regression model (two-variable model, multiple regression, functional forms, dummy variables); regression analysis in practice (model selection criteria and tests, multicollinearity, heteroskedasticity, autocorrelation), simultaneous-equations models. Statistical package 'R' will be used in this course.

MPBA G506 Data Management and Warehousing 3*

The database environment and the development process, Modeling data in organizations, Entity-Relationship diagrams, logical database design, and relational model, physical database design and performance, Structured Query Language (SQL), Database application architectures, Foundations of Data warehousing, Data quality and integration, Big Data analytics, Data, and database administration.

MPBA G507 Programming for Analytics 3*

Variables & data types, operators, conditional statements, iteration statements, functions, Objects, and classes for Python; Data structures – vectors, matrices, lists, tuples, dictionaries, data frames, Packages: using existing packages and creating new packages, Data loading: from CSV, MS Excel, JSON & SQL databases Data wrangling: describing, summarizing, manipulating, and handling missing values of data in data frames; perform an operation such as delete values, find unique values, drop duplicate values, grouping, and performing loop operations over columns or rows; merging data frames; handling categorical data; handling time-series data, handling text data, web scraping, and handling images. Basics of version control using Github. Primary languages are R and Python.

MPBA G508 Strategic Management**3 0 3**

Overview of strategy, Crafting Strategy, company's strategy and its business model; Environmental Scanning, General Environment, Task Environment, STEEP analysis, Industry analysis; Resource based view of firm, Core competence, Distinctive competence, Competitive Advantage, Sustainable competitive advantage, Value Chain analysis; Strategy Formulation; Corporate strategy, business strategy, functional strategy; Strategy Implementation; Strategy Evaluation; Advanced Topics of strategic management: Blue Ocean Strategy, Ethical Issues and conduct.

Equivalent: MBA G566

MPBA G509 Corporate Finance**3***

Basics of financial management, time value of money, valuation of securities, risk return and opportunity cost of capital, capital budgeting, WACC and company valuation, capital financing decisions – capital structure, working capital management, dividend decisions, Aspects of Mergers & Acquisitions, Risk Management, International Financing. Ethical versus legal standards in finance, Limited Liability, its Effects and Legal Responses, Insider Dealing and Market Abuse, Regulatory Competition and Regulatory Arbitrage.

Equivalent: MBA G559

MPBA G510 Operations & Supply Chain Management**3***

Strategic importance of Operations, Forecasting, Product planning, Management of Quality, Statistical Process Control, Process Strategy, Layout planning, Production Scheduling, Inventory Management, MRP, Supply chain Management: An Overview, Supply chain strategy, Supply chain performance measurement, Distribution networks, Order management and customer service, Sales and Operations Planning, Transportation, Digital Supply chain, IoT and Blockchain, Sustainability in Supply chain, Ethical supply chain.

Equivalent: MBA G558

MPBA G511 Data Visualization, Ethics and Data Privacy**3***

Data Visualization Tools: R, Rstudio; RMarkdown; Organising data for visualization; choosing right visualization; visualization in practice: continuous variables, categorical variables, time-varying variables, visualizing statistical summaries, spatial data with maps, dimension reduction, three dimensions, networks, and interactive visualizations. Primary packages for visualization: ggplot2 & shiny. Secondary packages: Matplotlib, and Plotly. Introduction to Ethics, Intellectual Property, Information Privacy, Privacy, and the Government, Computer and Network Security, Professional Ethics.

MPBA G512 Time Series Analysis and Forecasting**3***

Extrapolative and Decomposition Models, Introduction to Box-Jenkins Time Series Analysis, ARIMA Models, Estimation and Diagnosis, Metadiagnosis and Forecasting, Intervention Analysis, Autoregressive Error Models-The Nature of Serial Correlation of Error, Sources of Autoregressive Error, Autoregressive Models with Serially Correlated Errors, Tests for Serial Correlation of Error, Corrective Algorithms for Regression Models with Autocorrelated Error, Forecasting with Autocorrelated Error Models, Models with Stochastic Variance- ARCH and GARCH Models, A Review of Model and Forecast Evaluation. The course necessarily involves the use of statistical software and programming languages.

MPBA G513 Predictive Analytics**3***

An Introduction Predictive Analytics, Exploratory Data Analysis, Dimension-Reduction Methods, Preparing the Data for modeling, Decision Trees, Support Vector Machines, Regression Analysis Techniques, Naïve Bayes and Bayesian Networks, Clustering, Association Rules, Boosting and Bagging algorithms, Enhancing Model Performance. The course necessarily involves the use of statistical software and programming languages.

MPBA G514 Deep Learning for Business**3***

Introduction to deep learning, and example applications of deep learning algorithms to solve business problems; Basics of neural networks; Applying linear regression and logistic regression using

neural networks; Deep neural networks: concepts and hands-on applications; Model Building & Hyper- parameters tuning, Convolution Neural Networks (CNN), Recurrent Neural Networks, Deep reinforcement learning; Long Short Term Memory (LSTM); Generative Adversarial Networks (GANs); Challenges & limitations of deep learning algorithms

MPBA G515 Prescriptive Analytics with Mathematical Programming**3***

Linear Programming, Duality Theory, Sensitivity Analysis, Network Models, Integer Programs, Stochastic Optimization, Sequential Decision Making, Non-Linear and multi-Objective Optimization, Local Search and Meta-heuristics, Large-Scale Optimization, Monte Carlo simulation. The course necessarily involves the use of statistical software and programming languages.

MPBA G516 Advanced Spreadsheet & Macro Programming for Business**3***

Variables, Arrays, Constants, and Data Types, Modules, Functions, and Subroutines, Programming Basics, The Excel Object Model, Using Excel to Interact with Other Office Programs, Working with Databases, API Calls, Class Modules, Animation, Converting Labels to Numbers and Numbers to Labels, Transposing a Range of Cells, Adding Formula Details into Comments, Replacing Characters in a String, Auto Totaling a Matrix of Numbers, Coloring Alternate Rows and Columns of the Spreadsheet, Globally Changing a Range of Values, Searching Multiple Sheets and Workbooks, Brighten Up Your Comments, An Alternative to Message Boxes, Working with Shapes, Turning Your VBA Code into an Add-In.

MPBA G517 Big Data Analytics**3***

Hardware trends for data storage and computation, Big data in private and government sectors, Evolution of tools to handle big data, Apache Spark: for big data processing & engineering, Spark's Resilient Distributed Datasets (RDDs), Transformations and actions in Spark, Exploring big datasets using spark, Application of machine learning algorithms on big datasets through Spark, Application of deep learning algorithms on big datasets through Spark, Handling huge textual datasets and application of deep learning algorithms through Spark, Challenges.

MPBA G518 Bayesian Analysis**3***

Distributions; likelihoods, priors; intuition of building Bayesian models; Basics of Markov Simulations, building posterior distributions from MCMC simulations; single-parameter models, Multi-parameter models, Hierarchical Models; Generalised Linear Models, Model checking and comparison of models. The course necessarily involves the use of statistical software and programming languages.

MPBA G519 Natural Language Processing for Business**3***

Natural language processing and its neighbors, Themes in Natural language processing, Types of textual data, Preparing textual data for analysis, Regular expressions and patterns matching, term frequency times inverse document frequency, Word to vector representations (word embeddings), and feature engineering, Text classification or Topic Modeling, Text to knowledge conversion: Knowledge graph construction, N-grams, and analysis of word networks in text, logical semantics, predicate argument semantics.

MPBA G520 Analytics for Supply Chain**3***

Supply chain performance, Descriptive analytics, Supply chain forecasting, studying holt, winter and ARIMA models, Supply chain segmentation. Single period and multi-period inventory modeling, Multi-echelon inventory models, Network flow models, Distribution planning, Sales, & Operations planning, Vehicle routing problems, Simulation in supply chain risk assessment.

MPBA G521 Supply Chain Finance**3***

Financial flexibility, Supply chain, and finance link, SCOR model, Financial measures, Trade finance tools, operational hedging, enterprise risk management (ERM), supply chain risk management

(SCRM), integrated risk management (IRM), supply chain finance (SCF), and financial management of supply chain strategies.

MPBA G522 Discrete Event Simulation 3*

Introduction to Simulation, Simulation Examples, General Principles, Simulation Software, Statistical Models in Simulation, Queueing Models, Random-Number Generation, Input Modeling, Verification and Validation of Simulation Models, Output Analysis for a Single Model, Some Simulation Applications.

MPBA G523 IT Project Management 3*

Project lifecycle, Scope of work, scope statement, scope creep, project planning, work breakdown structure, project network method, CPM, PERT, project cost estimation, function method, cocomo model, project crashing, project scheduling, time-phased budgeting, project monitoring and control, earned value method, agile project management.

MPBA G524 Marketing Analytics 3*

Introduction to marketing analytics, Pricing of Single and Bundled Products, Forecasting (Bass Diffusion Model, Copernican Principle), Demand Analysis (Conjoint Analysis, Logistic Regression, Discrete Choice Analysis), Seasonality, Neural Networks to Predict Sales, Customer Life-time Value, Allocation of Marketing Resources, Market Segmentation (Cluster Analysis, Collaborative Filtering, Classification Tree), Market Basket Analysis, Optimizing Direct Mail Campaigns, Allocating Retail Space and Sales Resource, Measuring Effectiveness of Advertising (Adstock Model), Media Selection Models (Linear Media Allocation Model, Monte Carlo Media Allocation Simulation), Online Advertising, Klout Score, Tipping Point, Watt's Model for Viral Marketing, Text Mining.

MPBA G525 Digital Analytics 3*

Understanding web analytics; Finding data for web analytics; Web analytics tools; Discovering bots; Knowing website visitors; Clickstream analytics; Identifying most important webpages; Key performance indicators; Increasing website visibility; Deciding online advertising strategy; Fine-tuning website; Competitive intelligence analysis; Understanding Social Media; Foundations of social, mobile and video analytics; Creating Value with Social Media Analytics; Analytics-Business Alignment; Capturing Value with Network Analytics, Text Analytics and Actions Analytics; Social Media Analytics Capabilities; Social Media Security, Privacy & Ethics. The course necessarily involves the use of statistical software and programming languages.

MPBA G526 Pricing Analytics 3*

This course provides an introduction to both the theory and the practice of revenue management and pricing. Fundamentals of price theory, Segmentation and price differentiation, Break-even analysis, Price sensitivity and willingness-to-pay, Empirical estimations of price-response functions, Price optimization, Mark-down optimization, The hedonic pricing model, Revenue Management, Big Data and pricing analytics, Monte Carlo simulation for pricing decisions, Conjoint analysis for pricing decisions. The course necessarily involves the use of statistical software and programming languages.

MPBA G527 Retail Analytics 3*

Retail business's business intelligence environment, retail processes, methods, and technologies, retail information systems, retail consumers, data-driven tools and theoretical analytical models, analytical tools for retail, statistical methods in econometrics and machine learning like -single and multivariate linear regressions, logistic regressions, and classification trees, merchandising analytics, customer analytics, managing in-store environment & operations, inventory, sales and its trends, loyalty marketing and 'retail data reporting & visualization'. The course necessarily involves the use of statistical software and programming languages.

MPBA G528 Customer Engagement and Analytics 3*

Customer acquisition: RFM scoring, Customer characteristics, Company-interaction variables, Clickstream data, Linear regres-

sion model, logit/probit model, transaction usage clustering, Probability models. Customer development: Regression model, logistic regression model, Markov decision process, Structural equation model. Customer retention: Dependence between customer value, customer engagement and churn probability, Non-parametric models. The course necessarily involves the use of statistical software and programming languages.

MPBA G529 Marketing Research & Metrics 3*

Elements of marketing research process viz. Problem Definition, Development of an approach to the Problem, Research Design formulation, Exploratory, Descriptive and experimental, Fieldwork & Data collection, Data preparation & Analysis, univariate, bivariate and multivariate statistical techniques, Report preparation and Presentation. Marketing metrics. Nonfinancial metrics: Brand awareness, Test drive, Churn, Customer satisfaction (CSAT) and Take rate; Financial metrics: Profit, Net present value (NPV), Internal rate of return (IRR), Payback, Customer lifetime value (CLTV), Cost per click (CPC), Transaction conversion rate (TCR), Return on ad dollars spent (ROA), Bounce Rate and Word of mouth (WOM).

Equivalent: MBA G560

MPBA G530 Financial Analytics 3*

Financial Statistics, data exploration using fundamentals, returns evaluation, gauging market sentiment, prediction using fundamentals, forecasting financial time-series, portfolio analytics: Sharpe ratio, Markowitz mean-variance optimization, portfolio allocation using regularization, portfolio strategies, dynamic portfolio selection, portfolio tracking, and rebalancing, Simulating Trading Strategies. Market structure, mechanics of algorithmic, taxonomy of data used in algorithmic trading, market microstructure, high-frequency data, computational resources and algorithms for high-frequency trading.

MPBA G531 Financial Derivatives and Analysis 3*

Futures and Forward Contracts: Futures Markets, Currency Futures, and Forward Contracts, Equity Index Futures, Interest Rate and Bond Futures and Forward Contracts, Fundamental of Options Trading, Option Strategies, Option Hedging, Option Pricing, The Binomial Option Pricing, The Black-Scholes Option Pricing Model, Pricing Non-Stock Options and Future Options, Pricing Bond and Interest Rate Options, Financial Swap, Credit Default and Currency Swaps.

MPBA G532 Financial Modelling and Valuation 3*

Introduction to valuation, the role of financial statements, steps in business valuation, different approaches to valuation, strategy analysis, accounting analysis, financial analysis, prospective analysis, deal analysis credit analysis, and corporate governance.

MPBA G533 Financial Technology 3*

Introduction to FinTech landscape, Blockchain technologies, Crypto-assets and their ecosystem, FinTech Business Plans, FinTech Start-ups, Technology Stack Evaluation to develop fintech products, Payments, Lending, FinTech in Incumbents, InsureTech, AI in Finance, Regulations in FinTech, Risks in fintech, Identify opportunities in emerging internet and finance sectors and develop a fintech product, Evaluation of the market potential of fintech-startup, fund-raising for fintech start-ups, Cryptocurrencies disruption in venture capital funding.

MPBA G534 People Analytics 3*

Introduction to People Analytics, HR Business Processes and HR Analytics, People Analytics and Data, Descriptive Analytics: Data Visualization in HR using Excel and Tableau, Predictive Analytics: Application of GLM procedures using MS Excel and R Commander, Predictive Analytics: Application of Supervised and Un-supervised Learning, Text Analytics: Applications in Orange

MPBA G535 Strategy Analytics 3*

Creating competitive advantage through Data; Role of analytics in strategic management; Drawing insights from data for environmental scanning; Analytics concepts for strategy formulation & prioritization; optimization tools & techniques for strategy imple-

mentation; Metrics for strategy evaluation & control; Designing intelligent information System for key stakeholders; Solving real-life case problems using analytical tools.

MPBA G536 Knowledge Management and Digital Strategy 3*

This course introduces the models and definitions of Knowledge Management, The information management cycle, Policies, tools, and techniques for knowledge management, Digital Trends: Big data, business analytics, and artificial intelligence. Knowledge management strategy, Digital strategy and business models of technology companies, Role of social media strategy in supporting knowledge flows, Enablers and barriers in knowledge sharing and knowledge transfer, Learning Organisations, Communities of Practice, Artificial Intelligence (AI) ethics, and the future of professions.

MPBA G537 Data Structures and Algorithmic Thinking 2 1 3

Recursion and backtracking, Linked List and Arrays, Stack and Queues, Trees, Priority Queues, Maps and Hash Tables, Disjoint Sets, Graphs, Text Processing

Pre-requisite: MPBA G507 Programming for Analytics

MPBA G538 Critical Product Management 3*

Purpose and role of a PM, PM: Myth vs. Reality; Telling Your Product Story; Deeper Dive into Product Build, UX research, UX Design Sprints, User Experimentation (A/B Testing), PM - UX Partnership, Technical savviness to give directions to and mentor Engineering, Writing PRFAQ and/or PRD; Data Experimentation & Measurement Programs; Ensuring a successful product, GTM strategy, Naming, Pricing, Launch; Stages: Private Preview, Limited Preview, General Availability (or as known as alpha, beta, general release); Having difficult conversations and prioritizations: Build the Product Roadmap; Strategy: Short term vs. Long term; Analytics: From Vision to Metrics to Insights (North Star, Counter Metrics, Guardrail Metrics), Adding color to analytics; Soft skills.

Mechanical Engineering

ME F110 Workshop Practice 0 4 2

Laboratory exercises for different manufacturing processes like machining on lathe, drilling, grinding, milling and shaper; sand moulding and casting; metal forming; joining processes like arc welding, gas welding, brazing and soldering; carpentry; fitting; use of metrology equipments in measurement; demonstrations on CNC machines and CNC part programming.

ME F112 Workshop Practice 1 1 2

Engineering materials, casting, forming, machining, joining, powder metallurgy, additive manufacturing, plastic processing, various other manufacturing processes and related laboratory exercises.

ME F211 Mechanics of Solids 3 0 3

Fundamental principles of mechanics, introduction of mechanics of deformable bodies, force and moment transmitted by slender members (2D truss, frame, beam), stress and strain, stress-strain-temperature relations, torsion of circular member, stress and deflection due to bending, buckling of columns, theories of failure.

ME F212 Fluid Mechanics 3 0 3

Fluid statics, fundamental of mass, momentum and energy transfer, control volume approach and integral equations, differential analysis of mass, momentum and energy transfer, solutions for one-dimensional steady-state situations, viscous and inviscid flow, dimensional analysis, compressible fluid flow.

ME F213 Materials Science & Engineering 2 0 2

Introduction, Structure of Materials (Metal and Ceramics), Dislocations, heat treatment of steel and strengthening Mechanisms of Metals, Phase diagrams, Iron-carbide phase diagram, Phase transformation in Metals, Mechanical and thermal properties of Metals, Polymers (Structure, processes and properties), powder metallurgy.

ME F214 Applied Thermodynamics 3 0 3

Availability and irreversibility, thermodynamic relations, gas and vapor cycles, combined power generation cycles, gas mixtures, refrigeration cycles, psychometrics and heat load calculations, gas turbine cycles, compressors, boilers and accessories

ME F215 Mechanical Engineering Laboratory 0 2 2

The course shall aim to train the student in the skill of operation of instruments and equipments. Testing of mechanical properties like tensile testing, hardness, impact, bending of beams, spring testing, basic fluid mechanics experiments like measurements of pressure, temperature, viscosity, flow measurement, basic electrical & electronics like experiments on diodes, rectifiers, OPAMPS, dc motors, transformers, induction and synchronous motors.

ME F216 Materials Science and Engineering 2 1 3

Introduction, structure of materials (metals, ceramics, and polymers), crystalline structure imperfections, amorphous and semi-crystalline materials, correlation of structure to properties, phase diagrams & phase transformation, solidification, diffusion and heat treatment, mechanical behaviour of material. Composites, advanced-smart materials, and functional materials, criteria for material selection, economic environmental, and societal issues. Experiments related to materials testing and characterization such as tensile, torsion, hardness, impact, non-destructive testing, XRD, SEM, etc.

Equivalent: MF F216

ME F217 Applied Thermodynamics 3 1 4

Thermodynamics relations, gas and vapour cycles, combined power generation cycles, gas mixtures, refrigeration cycles, psychometrics and heat load calculations, gas turbine cycles, compressors, boilers, and accessories; Experiments related to applied thermodynamics and fluid mechanics courses.

ME F218 Advanced Mechanics of Solids 2 0 2

3D stress, strain, and generalized Hooke's law, energy methods, torsion of noncircular members, shear center and asymmetrical bending, curved beams, and thick cylinders.

ME F219 Manufacturing Processes 3 1 4

Metal casting: different types of casting processes, casting analysis, and defects. Metal forming process analysis and defects. Welding, brazing, and soldering process and defects. Machining processes and analysis, machine tools, and cutting tool geometry. Polymer processing, metrology, and instrumentation: limits, fits, and tolerances. Related laboratory experiments.

ME F220 Heat Transfer 3 1 4

Fundamental concepts of heat transfer, steady-state and unsteady-state heat conduction, analytical and empirical relations for forced and free convection heat transfer, heat exchanger analysis and design, heat transfer by radiation, boiling, and condensation, introduction to mass transfer; associated laboratory.

ME F221 Mechanisms and Machines 3 0 3

Kinematics of mechanism: introduction to mechanisms, position, displacement, velocity, acceleration analysis, synthesis of planar mechanism, cam design, kinematics of gears, gear trains, dynamics of machines: static force analysis, dynamic force analysis (planar), dynamics of reciprocating engines, balancing, flywheels, gyroscopes, introduction to spatial & compliant mechanism, exposure to modeling and simulation tools.

Equivalent: MF F221

ME F241 Machine Design & Drawing 3 1 4

Fundamentals and principles of Design. Design and selection of Machine elements such as shafts, Screw fasteners, Welded joints, Springs, Brakes & Clutches, Bearings & Gears. Fundamentals of Machine Drawing; practices for Orthographic drawing of machine parts, sectional view, assembly drawing & exploded view.

ME F242 IC Engines	2 0 2	ME F317 Engines, Motors, and Mobility	2 0 2
Working cycles and operation of two stroke, four stroke SI and CI engine cycles. Ignition, combustion, alternative fuels, emission and their control.		Introduction - injection & ignition systems, lubrication, and cooling, measurement, and testing, emissions and control; fuel-air cycles; actual cycles; conventional fuels; combustion; alternate fuels; modern mobility solutions; electric and hybrid vehicles; comparisons of conventional vehicles with electric vehicles in terms of advantages, disadvantages, and applications.	
ME F243 Production Techniques I	2 1 3	ME F318 Computer-Aided Design	1 2 3
Metal casting methods, patterns and molding, different types of casting processes, injection molding, die casting and casting defects. Casting analysis. Metal forming, different bulk metal forming processes like rolling, extrusion, forging and wire drawing. Metal forming process analysis and forming defects. Welding, brazing and soldering, different techniques and welding defects. Welding analysis. Simple description of various machining operations, machine tools and cutting tool geometry. Limits & Fits and Metrology. Fabrication project.		Mathematical modeling of parametric curves, surfaces and solids. Geometric transformations, isometric transformations including translation, scaling, reflection, and rotation using specialized solid modeling packages. CAD/CAM data exchange. Introduction to FEM & FEA practice on a specialized CAE package. Modeling and simulation based practical exercises related to geometric modeling, finite element analysis, and machine drawing such as orthographic drawing, sectional view, assembly drawing & exploded view.	
ME F244 Kinematics & Dynamics of Machinery	3 0 3	ME F319 Vibrations and Control	3 0 3
Kinematics of mechanism: introduction to mechanisms, position, displacement, velocity, acceleration analysis, Synthesis of mechanisms (Planer), cam design, Kinematics of gears (spur, helical, bevel and worm), gear trains, Dynamics of machines: static force analysis, dynamic force analysis (planar), dynamics of reciprocating engines, balancing, cam dynamics, flywheels, governors and gyroscopes.		Small oscillations of linear dynamical systems, free and forced vibrations of single and multi-degree-of-freedom systems, normal modes and orthogonality relations, generalized coordinates, and Lagrange's equations, matrix formulation, eigen-value problem, and numerical solutions, transient response of one-dimensional systems. Introduction to continuous system, vibration measurement and analysis, closed loop control, conventional and non-conventional control strategies, transfer function, dynamic response, and stability criteria, state space approach and exposure to simulation tools.	
ME F266 Study Project	3	ME F320 Engineering Optimization	3 0 3
These courses include projects which are oriented towards readings from published literature or books about new frontiers of development or analysis of available database. These courses are normally available to students in second or higher levels. These courses must coterminate with project reports.		Formulation of optimization problems, classical optimization techniques, nonlinear optimization methods for problems with and without constraints, simplex method, duality and sensitivity concepts, revised simplex methods, transportation models, travelling-salesman models, assignment models, network models, integer programming, genetic algorithm and other evolutionary optimization techniques, goal programming and multi-objective optimization. Use of application softwares in solving optimization problems.	
ME F311 Heat Transfer	3 1 4	Equivalent: MF F320	
Fundamental concepts of heat transfer; steady state and unsteady- state heat conduction; analytical and empirical relations for forced and free convection heat transfer; heat exchanger analysis and design, heat transfer by radiation; associated laboratory.		ME F321 Data Mining in Mechanical Sciences	2 1 3
ME F312 Advanced Mechanics of Solids	3 0 3	Introduction to data mining, clustering, classification & association, sequence analysis, regressions method, decision trees, machine learning, neural networks, SVM for engineering and manufacturing applications, data mining for product design, applications of data mining in production, planning and scheduling, data mining for defect identification, process and quality control, application of data mining in maintenance, data analysis for machine and manufacturing process monitoring, introduction to cyber physical systems, introduction to big data handling and big data analytics.	
Generalized Hooke's law; Energy methods; torsion of non-circular members; shear center and asymmetrical bending; curved beams; thick cylinders; plates and shells; contact stress.		ME F323 Energy Storage Technologies	3 0 3
ME F313 Production Techniques II	3 1 4	Introduction, necessity of energy storage, classification, principles, challenges, comparison and applications of energy storage technologies. Mechanical energy storage: Flywheel, compressed air and pumped hydro energy storage. Thermal energy storage: Sensible heat, cryogenic storage, phase change materials, latent heat enthalpy, charging and discharging, thermochemical energy storage, sorption and desorption reactions. Electrochemical energy storage: Lead-acid batteries, ionic batteries, fuel cells, flow batteries, super-capacitors. Chemical energy storage: Hydrogen storage methods, power-to-gas and synthetic fuels. Challenges and solutions through different energy storage technologies.	
Metal cutting theory. Analysis, economics and quality control of metal cutting, laboratory exercises in metal cutting and fabrication project. Different machine tools their description and operation. Non-traditional machining processes. Micro-manufacturing technologies. Introduction to computer aided manufacturing (CAM), CNC machines and CNC part programming.		ME F324 Cell and Tissue Biomechanics	3 0 3
ME F314 Design of Machine Elements	3 0 3	Vector and tensor calculations, kinematics, balance laws, stress/strain tensors, constitutive equations for soft biological materials and rubber elasticity, introduction to viscoelasticity, mechanical behaviour of biological materials with emphasis on their microstructure (anisotropy), overview of biological growth and remodelling, introduction to cell mechanobiology, diffusion and	
Design methodology, fundamental principles, materials, design for static failure, design for fatigue failure, design and selection of machine elements such as shafts, screw fasteners, welded joints, springs, belt drive, brakes & clutches, bearings & gears.			
Equivalent: MF F314			
ME F315 Advanced Manufacturing Processes	2 1 3		
Unconventional manufacturing processes and analysis, micro-manufacturing technologies, introduction to computer-aided manufacturing, CNC machines, CNC part programming, additive manufacturing, modeling & simulation of manufacturing processes, surface technologies. Related laboratory exercises and fabrication project.			
ME F316 Manufacturing Management	2 0 2		
Introduction to manufacturing systems, forecasting, life cycle concepts, facility location and layout planning, aggregate and batch production planning, scheduling, inventory control, material requirement planning, and enterprise resource planning, just-in-time and lean manufacturing, total quality management, supply chain management and Industry 4.0.			

transport in biological systems, introduction to experimental techniques like biaxial mechanical testing of tissues, digital image correlation, atomic force microscopy, micropipette aspiration etc.

ME F325 Fundamentals of Soft Matter 3 1 4

Fundamental concepts - Introduction, examples of soft matter, intermolecular forces, scaling laws, phase transition, viscoelastic nature, Brownian motion, Polymers – Architecture, copolymers, random walk model, polymer elasticity. Colloids – forces between colloidal particles, properties of colloids, gels, foams, and micro-emulsions, applications of colloids. Surfaces, interfaces, and surfactants – Surface tension, wetting, capillarity, thermo-capillarity, Marangoni stress driven droplet migration, self-assembly, liquid-liquid interface, solid-liquid interface. Active matter -self-diffusiophoresis, squirmer model, fabrication. Biological soft matter – lipid bi-layer membranes, Polymersomes, biopolymers, DNA, proteins.

ME F340 Introduction to Sports Engineering 3 0 3

The course essentially prepares engineering students to utilize their existing technical knowhow for sports applications. The specific topics will include, working with human and human movement patterns, qualitative and quantitative techniques for analysis of human movement. Sports performance measure and analysis. Anthropomorphy, Ergonomics and Task design. Computer application in sports, computerized performance measure. Sports surface and its impact on sports performance, surface testing methods. Sports and training equipment case study, business around sports.

ME F341 Prime Movers & Fluid Machines 2 1 3

Theoretical analysis of energy and momentum transfer between fluid and rotor; principles of axial, mixed and radial flow compressors, turbines and pumps; design considerations; cascade aerodynamics and performance limitations; applications to power plant systems; model similitude for turbo-machines; Introduction to fluid power system, laboratory exercises in testing reciprocating machines, rotary machines and fluid power system.

ME F342 Computer Aided Design 3 1 4

CAD software and CAD hardware. Mathematical modeling of parametric curves, surfaces and solids, and their computer simulation on spreadsheets and using specialized solid modeling packages. CAD/CAM data exchange. Introduction to finite element analysis and FEM practice on a specialized CAE package. Rapid prototyping. Students will be required to do several assignments and one CAD project.

ME F343 Mechanical Vibrations 3 0 3

Small oscillations of linear dynamical systems, free and forced vibrations of single and multi-degree-of-freedom systems, normal modes and orthogonality relations, generalized co-ordinates and Lagrange's equations, matrix formulation, eigenvalue problem and numerical solutions, transient response of one-dimensional systems, approximate energy methods, continuous system, vibration of string, rods, bars and beams. Introduction to control systems.

ME F344 Engineering Optimization 2 0 2

Linear programming methods, simplex method, transportation model and its variants, queuing systems, PERT/CPM, Optimal problem formulation, engineering optimization problems, single variable optimization algorithms, multivariable optimization algorithms, constrained optimization algorithms.

ME F366 Lab Project 3

ME F367 Lab Project 3

These courses include projects involving laboratory investigation or laboratory development in the students discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

ME F376 Design Project 3

ME F377 Design Project 3

These courses are intended to impart training in design of product/ process or other artifact to the students in the discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

ME F411 Fluid Power Systems 3 1 4

Introduction to Fluid power, advantages of fluid power, applications, Introduction to Pneumatics, Air preparation and Components, Pneumatics Circuits and Applications, Electro pneumatics, Electrical Controls for fluid power circuits, Physical properties of hydraulic fluids, Energy and Power in Hydraulic Systems, Frictional Losses in Hydraulic Pipelines, Hydraulic Pumps, Hydraulic Cylinders and Cushioning Devices, Hydraulic Motors, Hydraulic Valves, Hydraulic Circuit Design and Analysis, Ancillary Hydraulic Devices, Hydraulic Conductions and Fittings, Maintenance of Hydraulic Systems, Use of PLC programming for interfacing pneumatics and Hydraulic Circuits.

ME F412 Production Planning and Control 3 0 3

Generalized model of production systems; types of production flows; life cycle concepts; facilities location and layout planning; aggregate and batch production planning; inventory systems; materials requirements planning; elements of monitoring & production control.

ME F413 Nonlinear Vibrations 3 0 3

Introduction, sources of nonlinearity, examples, qualitative analysis: phase plane, singular points, stability of singular points, Forced response, Perturbation methods: straightforward expansion, the method of multiple scales, harmonic balance, method of averaging, Nonlinear normal modes, Nonlinear Multiple-DOF Systems, Bifurcations, Centre manifold reduction, Floquet Theory, Chaos Theory, Melnikov Criterion, Applications to vehicle dynamics, structures and microsystems etc. Use of softwares for simulations and numerical solutions.

ME F414 Fuel Cell Science and Technology 3*

Introduction to fuel cell, types, advantages and applications; Fuel cell thermodynamics, electrochemistry, charge transport, heat and mass transport; Fuel cell modelling and simulation. In-situ, ex-situ experimental characterization techniques viz. polarization curve, electrochemical impedance spectroscopy, current density mapping etc. Polymer electrolyte membrane fuel cell including direct liquid fuel cell; Other fuel cells viz. SOFC, AFC, MCFC, PAFC, biological fuel cells etc. and recent development.

ME F415 Gas Dynamics 3 0 3

Introduction to Gas Dynamics, Basic equations of compressible flow, Wave propagation, Steady one-dimensional flow (Varying-area adiabatic flow), Normal shock waves, Oblique shock and expansion waves, Prandtl-Meyer Flow, Flow with Friction and Heat Transfer, Potential equation for compressible flow, Similarity rule.

ME F416 Reverse Engineering and Rapid Prototyping 3 0 3

Introduction to reverse engineering, methodologies and techniques for reverse engineering, reverse engineering hardware and software, selecting reverse engineering system, introduction to rapid prototyping, relationship between reverse engineering and rapid prototyping. Reverse engineering in automotive engineering, aerospace engineering, medical device industry. Legal aspects and barriers for reverse engineering. Project work.

ME F417 Advanced Metal Forming 3 0 3

The stress and strain tensors in macroscopic plasticity and failure criteria for metal forming, effective stress and effective strain, flow rules for plastic deformation and principle of normality. Work hardening, determination of work hardening exponent. Plastic instability and effect of inhomogeneity on uniform strain. Strain rate and temperature effects on plastic deformation and flow stress, superplasticity, temperature rise during metal forming. Ideal work and redundant work. Slab, upper-bound, slip-line field and finite element methods of analysis of various bulk and sheet metal forming

processes. Bulk and sheet metal formability tests and forming limit diagram. Sheet metal properties and plastic anisotropy.

ME F418 Rocket and Spacecraft Propulsion 3 0 3

Thrust and specific impulse. Compressible flows. Detailed analysis of liquid, solid and hybrid propulsion systems. Includes propellants, injection systems, combustion and chemical equilibrium, thrust chambers, nozzles and plumes. Electro-thermal thrusters. Plasmas and electromagnetic thrusters.

ME F419 Total Product Integration Engineering 3 0 3

Quality design across global supply chain. Robust product architecture for market variety and technology advances. Product development risk management.

ME F420 Power Plant Engineering 3 0 3

Classification of power plants. Components and layout of; thermal, nuclear, hydro electric power plants. Site selection for various power plants. Combined cycle power plants. Magneto Hydro Dynamics (MHD) systems. Economics of power generation, economic loading of power stations. Load curve analysis; load factor, diversity factor. Power plant instrumentation and controls.

ME F423 Micro Fluidics and its Application 4*

Introduction to microfluidics, scaling in microfluidics, theoretical microfluidics, Philosophy of Computational Fluid Dynamics, Concepts of discretization, fabrication techniques for microfluidic devices, microvalves, micropumps, microflow sensors, microfluidics for life sciences: micromixers, microneedles, microfilters, micro-separators, microreactors, modeling and simulation on CAD tool.

ME F424 Energy Management 3 0 3

World and Indian energy scenario; energy policy; energy management principles; energy conservation; energy auditing; analysis; formulation of energy management options; economic evaluation; implementation & control; energy conservation techniques – conservation in energy intensive industries; choice of fuels and stoichiometry, steam generation, distribution systems, and electrical systems; integrated resource planning; demand-side management; cogeneration; total energy schemes; thermal insulation; energy storage; economic evaluation of conservation technologies; analysis of typical applications.

ME F425 Additive Manufacturing 3 0 3

Introduction to Additive Manufacturing (AM), generalized AM process and process chain, different materials used in AM, Use of multiple materials, multifunctional and graded materials in AM, Role of solidification rate. Various AM processes and their mechanics of operation. Vat polymerization processes, stereolithography. Powder based AM processes involving sintering and melting, selective laser sintering, direct metal laser sintering, selective laser melting, other polymer, ceramic, metal and alloy K-4 powder based AM processes. Extrusion based AM processes, fused deposition modelling (FDM). Sheet lamination processes, laminated object manufacturing (LOM). Micro- and nano-additive manufacturing processes; Modelling in Additive Manufacturing Transport phenomena models: temperature and fluid flow, molten pool formation, Various case studies - modelling of fusion based AM process, powder bed melting based process, droplet based printing process; Applications of Additive Manufacturing in Aerospace, Automotive, Electronics industries and Biomedical applications.

ME F426 Industry 4.0 in Manufacturing 3 0 3

Limitations of existing manufacturing systems, industrial revolution 4.0 for manufacturing, vision and strategy, organization and structure, models and standards, drivers and enablers, smart products, smart process, smart production, smart factories, smart networked industries, smart supply chain, lean and I4.0. I4.0 navigators: sensors, actuators, data analytics, connectivity, and AI. Economic evaluation of existing system for I4.0. Limitations of I4.0. Case studies.

ME F427 Continuum Mechanics 3 1 4

Introduction to tensors, tensor algebra and tensor calculus. Kinematics of deformation (displacement, velocity, deformation gradient,

material and spatial field descriptions, description of local deformation, linearized kinematics, kinematic rates), left & right Cauchy-Green deformation tensor, Cauchy-Lagrangian strain tensor. Traction and stress (first Piola-Kirchhoff stress, second Piola-Kirchhoff stress, Biot stress etc). Mechanical conservation and balance laws (conservation of mass, conservation of linear momentum, conservation of angular momentum, conservation of energy, work done by stresses and the principle of virtual work, BVP, IVP, calculus of variation). Constitutive relations (constraints on constitutive relations, frame indifference, objectivity, material symmetry, constitutive models for linearly elastic, hyperelastic solids and fluid flows).

ME F428 Smart Materials 3 1 4

Overview of smart materials. Piezoelectric materials (Ceramics and polymers), Electro and Magneto-Rheological Fluids, Shape Memory Alloys (SMA) – One way and two-way SMAs, Magnetic Shape Memory Alloys (M-SMA), Fiber optic sensors, Miscellaneous smart materials – Magnetostrictive, electrostrictive materials and others. Basic modelling of smart materials, Dynamics and control knowledge for smart materials. Applications in the field of civil, mechanical, aerospace, biomedical, energy industry such as sensors and actuators, vibration control and damping, structural health monitoring. Intelligent devices based on smart materials.

Pre-requisites: ME F216 or MF F216 or CHE F243

ME F429 Micro-Nanoscale Heat Transport 3 1 4

Introduction to energy carriers at micro/nanoscale, energy levels at micro/nanoscale, energy transport by waves and particles, energy quantization, energy states in solids, scattering and heat generation processes, statistical thermodynamics, micro/nanoscale heat transport: Phonon specific heat, thermal conductance, thermal conductivity, convection and radiation, entropy of energy states. Classical laws, Boltzmann transport equation, deviation from classical laws at micro/nanoscale, phonon-phonon transport, electron-phonon transport. Applications of micro/nanoscale heat transport: micro heat exchanger, micro heat pipes, thermoelectric devices, microchannel heat sinks, microelectronics, nanomaterials, nanoencapsulated heat storage materials, nanofluids, nanoscale thin films and nanosensors.

Pre-requisites: ME F220 OR CHE F241

ME F430 Fluid-Structure Interactions 3 0 3

Introduction to Fluid-Structure Interaction with examples of FSI systems, Coupling fluid and structural mechanics, Coupled fluid-structure equations; Small reduced velocities, Added stiffness and added mass, Computing added mass; Added damping, Sloshing, Coupling with sloshing; Introduction to Aeroelasticity, Flow-induced static instability, Flow-induced dynamic instability, Coupled-mode flutter; Fluid forces on a bluff body with non-circular cross-section, Fluid-induced instabilities, Galloping; Garden hose instability, Fluid-conveying pendulum, Fluid conveying pipes, Vortex-induced vibrations, Vortex-shedding patterns, Lock-in, Wake-induced flutter; Numerical simulation and modelling of FSI, Coupling fluid and structure codes; Monolithic and partitioned methods for FSI, Spatial and temporal coupling methods at fluid structure interface. Case studies on: Flutter of an aerofoil, Galloping of a square cylinder, Fluid-elastic instability of offshore risers and cylinder arrays.

Pre-requisites: ME F211: Mechanics of Solids, ME F212: Fluid Mechanics

ME F432 Computer Aided Manufacturing 2 1 3

Introduction, features of NC machine tools, NC part programming, CAM system devices, interpolators for manufacturing systems, control loops of NC systems, computerized numerical control, adaptive control systems, CAD to CAM, CAPP, industrial robots, computer aided production planning & control, computer aided inspection and quality control, CIM systems.

ME F433 Solar Thermal Process Engineering 3 1 4

Fundamentals of solar energy, earth-sun angles, solar spectrum, solar radiation, measurement and estimation of solar energy on horizontal and tilted surface, conversion routes and technologies, Standards and Performance Testing, thermal utilization of solar energy, modes of heat transfer and equations for performance

calculations of systems- conduction, convection and radiation of heat, Flat plate collectors, solar concentrator systems, geometric optics, tracking methods, thermal analysis, energy storage, materials and properties, solar process loads and system calculations for time dependent loads, Life cycle cost analysis and economic analysis for various applications of solar thermal processes, solar water heating, space heating and cooling in Buildings, Industrial process heating, solar air-conditioning and refrigeration, Use of Simulation tools for performance simulation and Project Assignments, solar thermal power generation, Role of Govt., policies and plans.

ME F434 Digital Twins in Mechanical Engineering 3 1 4

Digital Twins for condition monitoring and prognostics - Digital Twins for prognostics, fault diagnosis in rotating machines, electrical machinery faults, thermography, computer vision technique for wear debris analysis, acoustic analysis, Mathematical modelling and physics-based approach, communication protocols between physical and virtual systems, data-driven or AI/ML- based approach for digital twins, and hybrid approach. Digital twins in Manufacturing- operations improvement, tool condition monitoring, 3-D printing. Digital Twins in Aerospace systems and automobiles.

ME F435 Shape Memory Alloys: Fundamentals and Applications 2 1 3

Introduction to Shape Memory Alloys (SMA), Mechanism of shape memory effect and superelasticity, Ti-Ni, Cu, Fe – based SMAs, Magnetic SMA, Fabrication and experimental characterization of SMA, SMA Constitutive Modelling, Design and applications of SMA components in aerospace, biomedical and structural engineering, Experiments on shape memory effect, superelasticity, shape setting, spring design and fabrication, SMA component design, fabrication and demonstration for various applications.

ME F436 Sustainable Energy Informatics 3 0 3

Introduction, necessity of sustainable energy technologies, classification, principles, challenges, comparison and applications of different sustainable energy technologies. Basics of decarbonization, decentralization and digitalization of energy systems. Energy informatics: Internet of energy, energy blockchain, artificial intelligence tools and machine learning techniques used for energy data analytics, energy forecasting, optimization and management of next generation sustainable energy systems.

ME F437 Thermo-fluidic of Food Process Engineering 3 0 3

Review of basics of thermodynamics and fluid mechanics in the context of food engineering, thermo-physical properties of foods, energy and controls in food processing, heat transfer in food processing, preservation processes, refrigeration and freezing aspects of foods, evaporation processes in food processing, Dehydration processes of foods, design and analysis of equipment for all the above processes, case studies of these as applied to different kinds of foods.

ME F441 Automotive Vehicles 3 0 3

Internal combustion engines; vehicle performance; analysis and design of vehicle components. Experimental or theoretical investigation of problems selected from the field of automotive vehicles.

ME F443 Quality Control, Assurance and Reliability 3 0 3

Basic concepts of probability and probability distributions, standard probability distribution, sampling and sampling distributions, confidence intervals, testing significance, statistical tolerance, various types of control charts, statistical process control techniques, value analysis, defect diagnosis and prevention, basic concepts of reliability, reliability design evaluation and control, methods of applying total quality management, production process.

ME F451 Mechanical Equipment Design 3 0 3

Design analysis for additional machine elements; retainment of bearings and design of machine housing; introduction to techniques of optimisation reliability and value analysis; exercises in detail design; design solutions to meet specified functional requirements.

ME F452 Composite Materials & Design 3 0 3

Introduction to composites, concepts of reinforcement, strengthening mechanisms, fibrous reinforcements, matrix materials, micro-mechanical aspects of composites, manufacturing methods, composite production design methods-design of tensile members, pressure vessels, storage tanks, and other chemical process equipment made of FRP, design of joints, damage of composites by impact, FRP grids, recent development in manufacturing of composites and technologies.

ME F461 Refrigeration and Air conditioning 3 0 3

Principles, thermodynamic analysis, load estimates and design of various refrigeration and air conditioning systems for comfort and industrial applications. Theoretical or experimental investigation of refrigeration and air-conditioning problems.

ME F472 Precision Engineering 3 0 3

Concept of accuracy, accuracy of numerical control systems, tolerances and fits, acceptance tests for machine tools, static stiffness and its influence on machining accuracy, inaccuracies due to thermal effects, influence of forced vibrations on accuracy, dimensional wear of cutting tools and its influences on accuracy, clamping and setting errors, location principles and errors due to location, surface roughness and microfinishing processes, dimensional and dimensional chains, methods of improving accuracy and surface finish, thread and gear measuring instruments, coordinate measuring machines, introduction to computer aided tolerancing.

ME F481 Project Appraisal 3 0 3

Course Description is to be developed.

ME F482 Combustion 3 0 3

Fuels, Combustion, Adiabatic Flame Temperature, Chemical Kinetics, Chain Reactions, Conservation Equations for Reacting Flows, Laminar and Turbulent Premixed Flames, Diffusion Flames, Droplet and Particle Combustion, Emissions, Applications.

ME F483 Wind Energy 3 0 3

Historic development of wind energy technology, basic principles of wind energy conversion, different types of wind machines and their performances, wind rotor aerodynamics and its application in the turbine design, statistical methods of measurement and analysis of wind spectra for energy use, developing models for estimating the wind energy potential of a prospective site, Constructional features of various systems and sub-systems of a Wind Energy Conversion System (WECS), Features of wind farms, performance models of WECS, Optimal matching of WECS, environmental aspects of wind energy conversion, Economics of wind energy conversion.

ME F484 Automotive Technology 3 0 3

Automotive vehicle: layout, operating systems, components, materials and production processes; Power unit: IC engine, working principles, performance, systems and the associated parts; Mechanical unit: transmission, drive train, steering, chassis, suspension, brakes, wheels and tyres; Electric unit: battery, charging, starter and lighting; Electronic control unit: application of electronics and computers, sensors, actuators and on-board diagnostics; Latest Trends: advanced combustion systems and hybrid/fuel-cell/electrical power systems, alternate fuels and the emissions.

ME F485 Numerical Techniques for Fluid Flow and Heat Transfer 3 0 3

Introduction to CFD, Partial Differential Equation (PDE): Physical classifications, Mathematical Classifications, Well posed problem. Basic of Discretization Methods: Finite difference method, Truncation error, consistency, error and stability analysis, convergence, various discretization schemes. Introduction commercial software: OpenFOAM or Fluent. Application of numerical methods to selected model equations: Wave equation, Heat equation, Laplace's equations. Solution of Navier-Stokes equation for incompressible flows.

ME F491 Special Project	3	ME G532 Machine Tool Engineering	3 2 5
This is an unstructured open-ended course where under the overall supervision of an instructor-in-charge, batches of students will be attached to different instructors. Each batch will work on a specific time-bound project which is of basic or peripheral concern of his discipline. Each student must submit a project report as a culmination of his endeavour and investigation. The instructor-in-charge will determine the choice of the project and also whether or not the project report is to be submitted jointly by a group or individually by a student. The course will aim to evaluate student's actual ability to use the fundamentals of knowledge and to meet new unknown situations as demonstrated by the students' interaction with the instructors and instructor-in-charge and aggregated in the project report. The instructor-in-charge may assign specific hours for formal brain-storming sessions.		Design principles of machine tools; stiffness and rigidity of separate construction elements and their combined behaviour under load; design of stepped and stepless drives; electrical, mechanical and hydraulic drives; design of bearings and sideways; machine tool controls; machine tool dynamics; recent developments in machine tool design.	
ME G511 Mechanisms & Robotics	2 3 5	ME G533 Conduction and Radiation Heat Transfer	5*
Classification of robots & manipulators; fields of application; synthesis of planar & spatial mechanisms; methods of function & path generation; coupler curve synthesis; linkages with open loop; actuators & drive elements; microprocessor application and control of robots.		Conduction: Steady and unsteady problems and their solutions in cartesian, cylindrical and spherical coordinates. Separation of variables. Duhamel's theorem. Laplace transform. Problems involving change of phase. Inverse heat conduction, Microscale heat transfer, Radiation: Radiative exchange among black and grey and spectral surfaces, Shape factors. Applications to cavities and enclosures. Integral equations approach. Radiation from gases, vapours and flames.	
ME G512 Finite Element Methods	5	ME G534 Convective Heat and Mass Transfer	5*
Fundamental concepts, matrix algebra and gaussian elimination, one-dimensional problems, trusses, two-dimensional problems using constant strain triangles, axisymmetric solids subjected to axisymmetric loading, two-dimensional isoparametric elements and numerical integration, beams and frames, three-dimensional problems in stress analysis, scalar field problems, dynamic considerations, pre-processing and post processing.		Conservation equations, boundary layers, free convection, forced convection. Heat transfer in laminar and turbulent, internal as well as external flows, mixed convection. Combined convection and radiation. Boiling and Condensation. Molecular diffusion in fluids, mass transfer coefficient. Simultaneous heat and mass transfer; Applications.	
ME G513 Heating and Cooling of Buildings	3 2 5	ME G535 Advanced Engineering Mathematics	3 2 5
Introduction to HVAC design, basic scientific principles, climatic conditions, building heat transmission surfaces, infiltration and ventilation, heating loads, heat gains and cooling loads, HVAC psychometrics, codes and standards for HVAC systems design, acoustics and vibration, human comfort, air distribution, duct system design, fans and central air systems, air system heating and cooling, air cleaning and filtration, introduction to electrical systems, controls for air distribution systems.		Boundary value problems; wave equations; nonlinear partial differential equations; calculus of variations; Eigen value problems; iteration problems including forward and inverse iteration schemes – Graham Schmidt deflation – simultaneous iteration method – subspace iteration – Lanczo's algorithm – estimation of core and time requirements.	
ME G514 Turbomachinery	3 2 5	ME G536 Thermal Equipment Design	5
Introduction, thermodynamics, gas turbine plants, steam turbine plants, fluid dynamics, dimensional analysis and performance parameters, flow through cascades, axial turbine stages, high temperature turbine stages, axial compressor stages, centrifugal compressor stages, radial turbine stages, axial fans and propellers, centrifugal fans and blowers, and wind turbines.		Course description is to be developed.	
ME G515 Computational Fluid Dynamics	3 2 5	ME G537 Cryogenic Engineering	5
Philosophy of computational fluid dynamics (CFD), governing equations of fluid dynamics, mathematical behavior of partial differential equations, basics of the numerics : basic aspects of discretization, grids with appropriate transformations, and simple CFD techniques, applications, numerical solutions of quasi-one-dimensional nozzle flows, numerical solution of a two-dimensional supersonic flow, incompressible couette flow, and supersonic flow over a flat plate, advanced topics in CFD.		Introduction to cryogenics and its applications, properties of cryogenic fluids, properties of materials at cryogenic temperature, gas-Liquefaction and refrigeration systems, gas separation, cryocoolers, cryogenic insulations, vacuum technology, instrumentation in cryogenics, safety in cryogenics.	
ME G516 Energy Systems Engineering	5	ME G538 Toyota Production System	3 2 5
Basic concepts of energy conversion, generation of electrical and thermal energy, transmission and distribution of electrical energy, load management, detailed analysis of utilization of thermal energy in : boilers, furnaces, compressors, heat transfer equipments, and HVAC systems, energy audit, waste heat recovery systems, cogeneration, demand side management, and management and organization of energy saving projects.		Birth of Toyota production system, house of Toyota production system, stability, standardization, just-in-time, jidoka, involvement, hoshin planning, Toyota culture, Toyota way, Case Studies.	
ME G521 Mechanical System Design	3 2 5	ME G539 Computer Integrated Manufacturing	3 2 5
Concept of system design; modeling of structural and kinematic systems, and determination of system characteristics; reliability of systems; design of machine elements for specified reliability; concepts of optimization; techniques of design optimization for linear and non-linear problems.		Computer Modeling for mass property analysis. Computer Numerical Control. Computer-aided Manufacturing, operation of CNC machine tools. Design of manufacturing work cells, Automated Manufacturing and Programmable Controller.	
		ME G542 Advanced welding techniques	3 2 5
		A detailed overview of Friction welding, Explosive welding, ultrasonic welding, and hybrid welding process; working principle and applications; Heat distribution, metal flow in a liquid and semi-solid state; alloying element segregation, macro and microstructure in different weld zones; Selection of welding characteristics for underwater, extreme hot or cold, and in space conditions; Thermal modeling and simulations; governing transport phenomena equations, boundary conditions for individual welding processes; Estimation of the cooling rate, G/R ratio, and grain growth in weld zones.	
		ME G543 Natural Refrigerants and Application	5
		History of natural refrigerants, Growth in HVACR sector and energy consumption, Impact of refrigerants on environment. Thermodynamic properties of natural refrigerants (Ammonia, Carbon dioxide, Hydrocarbons, Water, Air), Challenges and opportunities of Natural refrigerants, Thermodynamic modelling of various natural refrigeration system. Low charge ammonia system, Transcritical CO2 system, high ambient application, chiller application,	

deep freezing application, natural refrigerant in secondary loop, Multi stage compression, Booster system, Cascade and multi evaporator system, simultaneous heating- cooling, high temperature heat pump. Technologies for performance enhancement & safety assurance. Component selection and design: Gas cooler, Internal heat exchanger, Sub cooler, Work recovery expander, Ejector, Economizer, Pressure exchanger, Defrost system, Oil management system, Accumulator, Electronic expansion valve, Variable speed drive, Compressors. Waste heat recovery and heat integration, Techno-economics of natural fluids.

ME G611 Computer Aided Analysis and Design 2 3 5

The course aims at developing complete self reliance in solving analysis & design problems of engineering with the aid of computers. It stresses upon the use of more powerful tools including system planning, simulation and modelling. The student will take up a design project and will work independently on the project guided by the instructor or resource person as and when required. The effort must culminate with a CAAD program and a project report.

ME G612Plastics Engineering 3 2 5

General properties of Plastics, Mechanical Behavior of Plastics, Processing of Plastics like Extrusion, injection moulding, thermoforming, calendaring, rotational moulding, compression moulding, transfer moulding, analysis of polymer melt flow, rheological models for polymer melt flow, analysis of heat transfer during polymer processing, elastic behavior of polymer melts, testing methods of polymers like DSC, TGA, DMA, XRD etc. FRP composites, Properties of FRP composites in longitudinal and transverse directions, volume and weight fraction relationships of fibers, failure mechanisms, mechanical properties and fiber orientation effects, processing of composite materials, advancement of composite materials in applications like wind mill blades, bullet proof jackets, etc.

ME G613 Advanced Finite Element Modelling & Analysis 3 2 5

Linear bending, modal and stability analysis of structures; incremental-iterative solution methods for nonlinear static and dynamic problems; nonlinear analysis considering geometric nonlinearity; elastoplastic analysis; alternative numerical approaches; industrial case studies on thermal analysis, coupled field analysis; fluid flow analysis; fatigue, creep and fracture, crash analysis, composite structures, shape optimization

Pre-requisite: CE F435 OR CE G619 OR ME G512

ME G621 Fluid Dynamics 2 3 5

Mechanics of turbulent flow; semi-empirical expressions; statistical concepts; stability theory; flow of non-Newtonian fluids; stationary and moving shock waves; Prandtl-Mayer expressions; two and three dimensional subsonic and supersonic flow; methods of characteristics; small perturbation theory and similarity rules.

ME G631 Advanced Heat Transfer 3 2 5

Heat conduction with unsteady boundary conditions; recent advances in natural and forced convection; condensation and boiling phenomena; heat transfer in high speed flows; liquid metal heat transfer, radioactive metal heat-transfer between surfaces in absorbing media; complex problems involving simultaneous conduction, convection and radiation.

ME G641 Theory of Elasticity and Plasticity 3 2 5

Basic equations of theory of elasticity; elementary elasticity problems in two and three dimensions; theories of plastic flow; problems in plastic flow of ideally plastic and strain hardening materials; theory of metal forming processes.

Microelectronics

MEL G512 Optoelectronic Devices, Circuits and Systems 3 2 5

Physics of optical radiation and principles of calculation in radiation physics & optics, fundamental laws of photometry. Interaction between optical radiation and matter. Radiation sources. Parameters of IR detectors and junction photodetectors, parameters

common to emitters and receiver, radiation measurements, optoelectronic components, optoelectronic integrated devices, photo-detector circuits, methods of modulation and optoelectronic system design and applications.

MEL G514 Nanoelectronic Memories and Technology 3 2 5

Introduction to memory devices in SRAM, DRAM and 3DNAND Flash, circuit and device considerations, device fabrication techniques and scaling avenues, memory array addressing, readout circuits, device characterization, reliability characterization. Non-volatile memory cell structures like (1T-1C 6T, 4T, 1T-1R, 0T-1R, 1S-1R, floating gate FLASH, SONOS, NROM), and memory organization (open bit-line, folded bit-line, NAND, NOR, cross-point etc.), new memory devices and concepts including (e.g. magnetic tunnel junction memory (MRAM, SST-RAM), ferroelectric memory (FRAM), phase change memory (PCM), metal oxide resistive switching memory (RRAM), nanoconductive bridge memory (CBRAM)

Pre-requisites:

EEE F214: Electronic Devices OR EEE F313: Analog and Digital VLSI design OR MEL G621: VLSI Design OR MEL G631: Physics and Modelling of Microelectronic Devices

MEL G531 Testable Design and Fault Tolerant Computing 3 2 5

Fault: types, modelling and simulation; testing methodologies, coverage, economics and quality; test vector generation: design for testability, built-in self tests; fault tolerant computing; fault tolerant software.

MEL G532 Digital Signal Processing 3 2 5

Introduction; design of analog filters; design of digital filters (IIR and FIR); structures for the realization of digital filters; random signals and random processes; linear estimation and prediction; Wiener filters; DSP processor architecture; DSP algorithms for different applications.

MEL G611 IC Fabrication Technology 3 2 5

Material properties; crystal growth and doping; diffusion; oxidation; epitaxy; ion implantation; deposition of films using CVD, LPCVD and sputtering techniques; wet and dry etching and cleaning; lithographic process; device and circuit fabrication; process modeling and simulation.

MEL G612 Integrated Electronics Systems Design 2 2 4

General architectural features of 8/16/32 bit microprocessors, programmers model of 8086, assembly language programming, hardware design around 8086, bus based systems design, system design around IBM PC, design of real-time systems, ASIC's development tools.

MEL G621 VLSI Design 3 2 5

Introduction to NMOS and CMOS circuits; NMOS and CMOS processing technology; CMOS circuits and logic design; circuit characterization and performance estimation; structured design and testing; symbolic layout systems; CMOS subsystem design; system case studies.

MEL G622 Introduction to Artificial Neural Networks 2 2 4

Fundamentals and definitions; Perceptrons, backpropagation and counterpropagation Networks; Statistical methods for network training; Hopfield nets; Associative memories; Optical neural networks; Applications of neural networks in speech processing, computer networks and visual processing.

MEL G623 Advanced VLSI Design 5

Deep submicron device behavior and models, Interconnect modeling for parasitic estimation, Clock signals and system timing-- Digital phase locked loop design, memory and array structures, Input/output circuits design, ASIC technology, FPGA technology, High speed arithmetic circuits design, -Parallel prefix computation, Logical effort in circuit design, Low power VLSI circuits-Adiabatic logic circuits, Multi threshold circuits, Digital BICMOS circuits, Design of VLSI systems.

MEL G624 Advanced VLSI Architectures 5

Instruction set design and architecture of programmable DSP architectures; dedicated DSP architectures for filters and FFTs; DSP transformation and their use in DSP architecture design; Application Specific Instruction set Processor; superscalar and VLIW architectures.

MEL G625 Advanced Analog and Mixed Signal Design 5*

Mixed signal blocks design issues,, design of high resolution, high speed Comparators,, design of Active Mixers-balanced/ unbalanced,, Data Converters Architectures, CMOS multipliers , dividers and modulators , filters-active/ passive/ switched capacitor, Signal Conditioning and sensor associated circuits, Frequency Synthesizers, Phase Locked Loop, Power Management Circuits, Integrated Voltage Regulators, Energy Harvesting Circuits,, Analog Testing, Analog layouts, noise issues, emerging trends.

MEL G626 VLSI Test and Testability 5

Fault models and types; automated test generation for combinational logic; test generation for sequential logic; need for adding testability logic; design for testability; Adhoc DFT methods; structured DFT; test generation for delay fault; issues in analog circuit testing and testability.

MEL G631 Physics and Modelling of Microelectronic Devices 3 2 5

Physics and properties of semiconductor - a review; pn junction diode; bipolar transistor; metal-semiconductor contacts; JFET and MESFET; MOSFET and scaling; CCD and photonic devices.

MEL G632 Analog IC Design 3 2 5

Basic Analog IC Design Issues, Analog Layouts, MOS Switch--Charge Injection, Current And Voltage Biasing and Reference Generation Circuits,Common Mode Feedback Circuit, Replica Bias, Design, Analysis and Synthesis of Single Stage Amplifiers, Differential Amplifiers, Operational Amplifiers and Operational Transconductance Amplifier Design, Low Power OPAMP , OPAMP/ OTA design in Subthreshold Operation region, Frequency Compensation, Current Mode Analog Circuit Design, Noise- Analysis and Estimation In Amplifiers, emerging trends.

MEL G641 CAD for IC Design 3 2 5

Introduction to VLSI design methodologies and supporting CAD tool environment; overview of 'C', data structure, graphics and CIF; concepts, structures and algorithms of some of the following CAD tools; schematic editors; layout editors; module generators; silicon compilers; placement and routing tools; behavioural, functional, logic and circuit simulators; aids for test generation and testing.

MEL G642 VLSI Architectures 2 2 4

Overview of CISC processor architectures; Instruction set architecture of CISC processor; hardware flow-charting methods; implementing microprocessor logic from hard-ware flowcharts; RISC instruction set architecture; Pipelined execution of RISC instructions; pipeline execution unit design; control hazards; design of memory hierarchy.

Manufacturing Engineering**MF F211 Mechanics of Solids 3 0 3**

Fundamental principles of mechanics, introduction of mechanics of deformable bodies, force and moment transmitted by slender members (2D truss, frame, beam), stress and strain, stress-strain-temperature relations, torsion of circular member, stress and deflection due to bending, buckling of columns, theories of failure.

MF F212 Fluid Mechanics 3 0 3

Fluid statics, fundamental of mass, momentum and energy transfer, control volume approach and integral equations, differential analysis of mass, momentum and energy transfer, solutions for one-dimensional steady-state situations, viscous and inviscid flow, dimensional analysis, compressible fluid flow.

MF F213 Materials Science & Engineering 2 0 2

Lattice structure and dislocations, binary phase diagrams , iron-ironcarbide phase diagram, heat treatment of steel, Phase transformation in Metals, Metallurgical techniques for property enhancement, Mechanical and thermal properties of Metals, and polymers, powder metallurgy. Material standards.

MF F214 Applied Thermodynamics 3 0 3

Availability and irreversibility, thermodynamic relations,Compressible flow, Ideal gas and vapour cycles, combined power generation cycles, gas mixtures, refrigeration cycles, psychrometrics and Introduction to heat load calculations, gas turbine cycles , compressors, boilers and accessories.

MF F215 Mechanical Engineering Laboratory 0 2 2

The course shall aim to train the student in the skill of operation of instruments and equipments related to Mechanical Engineering. Testing of mechanical properties like tensile testing, hardness, impact, bending of beams, spring testing, basic fluid mechanics experiments like measurements of pressure, temperature, viscosity, flow measurement, basic electrical & electronics like experiments on diodes, rectifiers, OPAMPS, dc motors, transformers, induction and synchronous motors.

MF F216 Materials Science and Engineering 2 1 3

Introduction, structure of materials (metals, ceramics, and polymers), crystalline structure imperfections, amorphous and semi-crystalline materials, correlation of structure to properties, phase diagrams & phase transformation, solidification, diffusion and heat treatment, mechanical behaviour of material. Composites, advanced-smart materials, and functional materials, criteria for material selection, economic environmental, and societal issues. Experiments related to materials testing and characterization such as tensile, torsion, hardness, impact, non-destructive testing, XRD, SEM, etc.

Equivalent: ME F216

MF F217 Machine Drawing 0 2 2

Fundamentals of machine drawing and dimensioning practice using conventional software, orthographic drawing of machine parts, sectional view, assembly drawing, exploded view, pictorial view, BOM, materials assignment and graphic rendering.

MF F218 Transport Phenomena in Manufacturing 3 1 4

Transport phenomena and its importance in manufacturing engineering, fundamentals of fluid mechanics, fluid statics, fluids in motion, heat and mass transfer theories, conservation laws for transport phenomena and solution methodologies, important solutions and correlations in transport phenomena, radiation heat transfer and special topics relevant to manufacturing such as heat transfer with phase change, simultaneous heat and mass transfer etc.

MF F219 Operations Management 3 0 3

Introduction to operations management, product planning, forecasting, facilities location and layout, process planning and design, performance measures and capacity planning, scheduling and controlling, material requirements planning and Just-in-time systems, inventory control, Introduction to Industry 4.0 and other advancements in operations management, case studies and software application.

MF F220 Metrology and Quality Assurance 2 1 3

Importance of metrology, calibration, limits fits and tolerances, design of gauges, linear and angular measurement, inspection of surface quality, features inspection, coordinate measuring systems, application of vision, interferometry, laser, and other non-contact measuring systems, various case studies on measurement systems used for automated production systems; quality management: practices, tools and standards, statistical techniques in quality control, statistical process control using control charts, control charts for attributes, and variables, process capability analysis, measurement system analysis, acceptance sampling plan, reliability assessment of systems and use of commercial software for SQC

MF F221 Mechanisms and Machines	3 0 3	MF F313 Metal Forming and Machining	3 1 4
Kinematics of mechanism: introduction to mechanisms, position, displacement, velocity, acceleration analysis, synthesis of planar mechanism, cam design, kinematics of gears, gear trains, dynamics of machines: static force analysis, dynamic force analysis (planar), dynamics of reciprocating engines, balancing, flywheels, gyroscopes, introduction to spatial & compliant mechanism, exposure to modeling and simulation tools.		Plastic deformation of metals and related properties, metal forming processes, Yield conditions and stress-strain relations, Theory of slip lines, upper and lower bound theorems, Analysis of various hot & cold metal forming processes, Mechanics of machining processes and analysis, thermal aspects and cutting fluids, grinding and finishing operations, non conventional machining processes.	
Equivalent: ME F221		MF F314 Design of Machine Elements	3 0 3
MF F222 Casting, Forming and Welding	3 1 4	Design methodology, fundamental principles, materials, design for static failure, design for fatigue failure, design and selection of machine elements such as shafts, screw fasteners, welded joints, springs, belt drive, brakes & clutches, bearings & gears.	
Pattern, mould and gating system design; casting processes, defects and inspection. Mechanics of forming processes; forming operations, friction and lubrication, forming defects. Principles of solid phase welding and liquid phase welding, soldering, brazing and adhesive bonding; newer welding processes, welding and additive manufacturing, weld defects and inspection; plastic processing and powder metallurgy.		Equivalent: ME F314	
MF F241 Machine Design & Drawing	3 1 4	MF F315 Automation and Control	3 1 4
Fundamentals and principles of Design. Design and selection of Machine elements such as shafts, Screw fasteners, Welded joints, Springs, Brakes & Clutches, Bearings & Gears, Fundamentals of machine drawing; practices for orthographic drawing of machine parts, sectional view, assembly drawing & exploded view.		Types of automation and its elements, sensors and signal conditioning, actuators; analog and digital systems, microprocessor / microcontroller systems, Arduino and other microcontrollers, communication systems, PLC, various case studies on mechatronic systems. Modelling of system behavior, stability analysis using control theory, transfer function approach, frequency response analysis (Nyquist and Bode plot), feedback control systems, various types of linear controller, tuning algorithms. Force and motion controllers, state space approach, exposure to the modelling and simulation tools.	
MF F242 Manufacturing Management	2 0 2	MF F316 Machining and Machine Tools	3 1 4
Introduction, product planning, forecasting, facilities location, process planning and design, layout of facilities, performance measures and capacity planning, planning and scheduling, material requirements planning and Just-in-time systems, inventory control, human resource management, financial management, marketing management, customer relationship management.		Significance of machining and machine tools, cutting tool geometry and materials, mechanics of machining processes, cutting fluids and their properties; abrasive machining processes and analysis, economics of machining, regulation of speed and feed rates in machine tools, design of machine tool structures, guideways, spindles; design of cutting tools for various machine tools; jigs and fixtures.	
MF F243 Manufacturing Processes	2 1 3	MF F317 Computer Aided Design and Manufacturing	2 1 3
Foundry practices and Metal casting methods, Plastic working of metals, Welding and cutting, Machining Processes and machine tools. Nonconventional manufacturing processes, Finishing and Cleaning processes, Limits & Fits. Production quality control, Manufacturing and environment.		Overview of CAD/CAM, principles of computer aided design, computer graphics fundamentals, 2D and 3D transformations and projections, plane curves, space curves, synthetic curves, analytical and parametric surfaces, synthetic surfaces, solid modeling basics, constructive solid geometry (CSG), sweeping; constructional aspects of computer controlled machines, CAM system devices, programming of computer controlled machines, CAD to CAM, virtual manufacturing, computer aided process planning, computer aided production planning and control, computer aided inspection, CIM.	
MF F244 Kinematics & Dynamics of Machinery	3 0 3	MF F318 Nontraditional Manufacturing Processes	3 0 3
Kinematics of mechanism: introduction to mechanisms, position, displacement, velocity, acceleration analysis, cam design, gear trains, synthesis of linkages. Dynamics of machines: static force analysis, dynamic force analysis (planar), dynamics of reciprocating engines, balancing, cam dynamics, flywheels, governors and gyroscopes, free and forced vibrations.		Mechanism and mechanics of cutting, process parametric analysis, process capabilities, applications and limitations of various nontraditional manufacturing processes (AJM, AFM, WJM, USM, MAF, MRF, EDM, WEDM, PAM, LBM, EBM, FIBM, ECM, ECG, ESD, etc.); introduction to micro and nanofabrication, micro forming, micro-joining, characterization of micro-machined structures, additive manufacturing: algorithm, technologies and processes such as SLA, FDM, SLS, LOM, DMLS, LENS, etc.; rapid tooling; reverse engineering.	
MF F266 Study Project	3	MF F319 Supply Chain Management	3 0 3
These courses include projects which are oriented towards readings from published literature or books about new frontiers of development or analysis of available database. These courses are normally available to students in second or higher levels. These courses must coterminate with project reports.		Cycle view and decision phases of supply chain, strategic fit & scope, supply chain logistical and cross functional drivers, metrics of supply chain drivers, designing the distribution network, planning demand and supply in supply chain, planning and managing cycle inventory, safety inventory and optimum product availability in a supply chain, transportation, sourcing and sustainability.	
MF F311 Mechatronics & Automation	2 1 3	MF F320 Engineering Optimization	3 0 3
Mechatronics design approaches, interfacing, instrumentation and control systems, modeling of mechanical and electromechanical systems, sensors and actuators, introduction to automation, pneumatics and hydraulics in automation, pneumatic circuits for automation, PLC programming and interfacing with pneumatic and hydraulic systems, introduction to MEMS, modeling and simulation of MEMS, CNC machines, automated material handling, introduction to FMS.		Formulation of optimization problems, classical optimization techniques, nonlinear optimization methods for problems with and without constraints, simplex method, duality and sensitivity concepts, revised simplex methods, transportation models, travelling-salesman models, assignment models, network models, integer programming, genetic algorithm and other evolutionary optimization	
MF F312 Tool and Fixture Design	3 0 3		
Tool-design methods, tool making practices, tooling materials and heat treatment, design of cutting tools, gages and gage design, locating and clamping methods, design of drill jigs, design of fixtures, design of sheet metal blanking and piercing dies, design of sheet metal bending, forming and drawing dies, using plastics as tooling materials, tool design for numerically controlled machine tools and automatic screw machines.			

tion techniques, goal programming and multi-objective optimization. Use of application softwares in solving optimization problems.

Equivalent: ME F320

MF F321 Procurement Management 3 0 3

Procurement scope and development, strategic procurement and supply chain management, outsourcing, quality management, lead time and time compression, sourcing strategies and relationships, price and total cost of ownership, negotiations, project procurement, procurement of commodities, capital procurement, retail procurement and efficient response, services procurement, e-procurement systems, sustainability, performance measurement, case studies.

MF F341 Design of Machine Tools 3 0 3

Determination of machining forces and power in turning, milling, grinding, drilling and shaper. Kinematics of machine tools and design of gearboxes, step-less regulation. Design of machine tool guide ways, beds, tables and columns. Design of power screws, spindle units and built-in inspection units. Bearings and lubrication in machine tools. Electric and hydraulic systems of machine tools. Introduction to dynamic analysis and vibrations in machine tools. Micro-displacement in machine tools, Design of CNC machines.

MF F342 Computer Aided Design 3 1 4

CAD software and CAD hardware. Mathematical modeling of parametric curves, surfaces and solids, and their computer simulation on spreadsheets and using specialized solid modeling packages. CAD/CAM data exchange. Introduction to finite element analysis and FEM practice on a specialized CAE package. Rapid prototyping. Hands-on in assignments and CAD project.

MF F343 Casting and Welding 3 1 4

Casting processes, Pattern and Mould design, metal melting and handling, metallurgical aspects of casting, Metal flow and heat transfer, analysis of casting defects. Injection moulding of plastics Gas cutting and welding processes including its physics, chemistry and metallurgy, power source characteristics, different welding techniques, selection of welding processes, destructive and non destructive testing of weldments welding standards and codes, analysis of welded joints, brazing and soldering.

MF F344 Engineering Optimization 2 0 2

Linear programming methods, simplex method, transportation model and its variants, queuing systems, PERT/CPM, Optimal problem formulation, engineering optimization problems, single variable optimization algorithms, multivariable optimization algorithms, constrained optimization algorithms.

MF F366 Lab Project 3

MF F367 Lab Project 3

These courses include projects involving laboratory investigation or laboratory development in the students discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

MF F376 Design Project 3

MF F377 Design Project 3

These courses are intended to impart training in design of product/ process or other artifact to the students in the discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

MF F411 Fluid Power Systems 3 1 4

Introduction to Fluid power, advantages of fluid power, applications, Introduction to Pneumatics, Air preparation and Components, Pneumatics Circuits and Applications, Electro pneumatics, Electrical Controls for fluid power circuits, Physical properties of hydraulic fluids, Energy and Power in Hydraulic Systems, Frictional Losses in Hydraulic Pipelines, Hydraulic Pumps, Hydraulic Cylinders and Cushioning Devices, Hydraulic Motors, Hydraulic

Valves, Hydraulic Circuit Design and Analysis, Ancillary Hydraulic Devices, Hydraulic Conductions and Fittings, Maintenance of Hydraulic Systems, Use of PLC programming for interfacing pneumatics and Hydraulic Circuits.

MF F412 Automotive Systems 3 0 3

Frame, suspension, springs and wheels, clutch and gear box, propeller shaft, universal joint, final drive, differential and rear axle, front axle and steering mechanism, brakes, automotive air conditioning, electrical vehicles, automotive electrical systems, automotive electronics systems.

MF F413 Mechanical Vibrations and Acoustics 3 0 3

Introduction, single degree-of-freedom systems: free and forced vibration problems, concept of resonance and damping, vibration isolation, multi-degree-of-freedom systems: modeling of multi-degree-of freedom systems, eigen value problem and calculation of normal modes of a system, forced response using modal superposition techniques, introduction to acoustics - terminology used in acoustics and definitive of fundamental quantities 1D wave, equation (plane waves) & 3D wave equation, formulation and fundamental solution to the equations, measurement of noise & vibration – vibration measurement principles.

MF F414 Manufacturing Excellence 3 0 3

Introduction, frameworks of manufacturing excellence, practices for manufacturing excellence: leadership and change management, manufacturing strategy, innovative product planning, total productive maintenance, total quality management, lean manufacturing, customer relations management, green manufacturing, supply chain management, knowledge management and social responsibility.

MF F415 Noise Engineering 3 0 3

Fundamentals of vibrations, vibrations of strings and bars, vibrations of membranes and plates, acoustic wave equation, acoustic energy and sound intensity, propagation of sound, concept of acoustic impedance, sound power transmission, transmission loss, human response and ratings, various measures of sound, weighting filters, loudness, indices of loudness, acoustic radiation from spherical source and piston source, acoustic sensors, measuring techniques and instruments, octave filtering, sound intensity measurement, intensity mapping, different types of measurement environment and uses, response of beam subjected to an acoustic plane wave, transmission loss of panels, sound absorption coefficient, noise control measures in building, reverberation time and auditorium design, industrial noise control, noise in machinery, traffic noise, vehicle noise, design of silencers and mufflers, active noise control, duct noise control and cabin noise control, practicals on noise measurements in different situations.

MF F416 Work System Design 3 0 3

Introduction to work systems design, productivity and work study, method study: process analysis, man-machine analysis, operation analysis and micro-motion study, introduction to ergonomics and principles of motion economy, work measurement: stop watch time study, work sampling, standard data and predetermined motion time systems, job enlargement and job enrichment, incentive schemes.

MF F418 Lean Manufacturing 3 0 3

Fundamentals of continuous improvement, value added and waste elimination, elements of lean production: small lot production, setup time reduction, maintaining and improving equipment, pull production systems, focused factories and group technologies, work cells and cellular manufacturing, standard operations, quality of design, systems for eliminating defects, simplified production planning and control systems: scheduling for smooth flow, synchronizing and balancing process, planning and control in pull production, beyond the production systems: managing the supply chain, activity based costing, performance measurement.

MF F421 Supply Chain Management 4

Customer driven strategies in production and distribution systems; Integrated production & distribution networks; SCM in the

context of JIT and MRP-II; Distribution Resource Planning; Management of dealer networks; Total Quality Control & product innovation across the supply chain; Incoming logistics & supplier relationships; Value addition analysis; Metrics for management of supply chain performance; Mathematical models and computer assisted decision support for SCM; mathematical programming for SCM.

MF F422 Supply Chain Modelling and Empirical Analysis 3 1 4

Contexts, issues and challenges in supply chain modelling and empirical analysis, buyer-supplier relationship, cultural implications, Primary and secondary data collection, questionnaire design, Model development and analysis with Statistical Packages such as SMARTPLS3, SPSS, Hugin and AMOS, Value Stream Mapping, Life Cycle Modelling, Model development and analysis with OpenLCA and EVSM, cost benefit analysis, Digital supply chain and Performance modelling, case studies

MF F442 Advances in Materials Science 3 0 3

Deformation of materials, deformation at high temperatures and creep, recovery, recrystallization and grain growth, fracture of materials and fatigue failure, deterioration of materials, corrosion and oxidation, surface properties, surface energy and tribology, polymers and fibre reinforced polymeric composites, mechanical testings, nondestructive testing techniques.

MF F453 Industrial Relations 3 0 3

Introduction to human resources management; planning and organising human resources; leadership and motivation; job satisfaction and morale; employee communication; audit and control; procurement of personnel; performance appraisal; human resource development; wage and salary administration; job change; discipline; labour welfare; trade unions and collective bargaining; industrial disputes; worker participation in management.

MF F463 Maintenance and Safety 3 0 3

Objectives, functions, and types of maintenance; defects due to wear; lubrication and surfacing techniques to reduce wear; maintenance of different equipments and their elements; spares planning; overhauling; TPM; safety and safety management; environmental safety; chemical safety; occupational health management; control of major industrial hazards; managing emergencies; employee participation in safety; HRD for maintenance and safety.

MF F471 Instrumentation and Control 3 0 3

Measurement systems, transducers, feedback control, components: electrical, hydraulic, pneumatic; Signal conditioning and processing, controllers, display, recording, direct digital control, programmable logic controllers, PC based instrumentation.

MF F472 Precision Engineering 3 0 3

Concept of accuracy, accuracy of numerical control systems, tolerances and fits, acceptance tests for machine tools, static stiffness and its influence on machining accuracy, inaccuracies due to thermal effects, influence of forced vibrations on accuracy, dimensional wear of cutting tools and its influences on accuracy, clamping and setting errors, location principles and errors due to location, surface roughness and microfinishing processes, dimensioning and dimensional chains, methods of improving accuracy and surface finish, thread and gear measuring instruments, coordinate measuring machines, introduction to computer aided tolerancing.

MF F473 Product Design and Development 3 0 3

Introduction to product design and development, product development planning and process tools, technical and business concerns, understanding customer needs, function modeling, benchmarking and engineering specifications, product architecture, concept generation, concept selection, concept embodiment, modeling of product metrics, design for X, physical prototypes, physical models and experimentation, robust design.

MF F474 Product Design and Development Projects 3

The course will essentially deal with the practice of product design and development. The student will involve in the design and development of different products. He will be guided by the instructor/resource person. The effort must culminate with a product along with the project report.

MF F485 Sustainable Manufacturing 3 0 3

Overview of sustainable manufacturing, 6R, WEEE, triple bottom concept of environment, economy and society, driver for, barriers to and stakeholders of sustainable manufacturing and their modelling, performance measures of sustainable manufacturing, evaluation of manufacturing systems based on environmental factors, eco-innovation and design for environment, recycling, remanufacturing, reuse, strategic and operational evaluation of technologies using life cycle management, environmental impact assessment models, end-of-life strategies, reverse logistics, sustainable product service systems, green factories.

MF F491 Special Project 3

This is an unstructured open-ended course where under the overall supervision of an instructor-in-charge, batches of students will be attached to different instructors. Each batch will work on a specific time-bound project which is of basic or peripheral concern of his discipline. Each student must submit a project report as a culmination of his endeavour and investigation. The instructor-in-charge will determine the choice of the project and also whether or not the project report is to be submitted jointly by a group or individually by a student. The course will aim to evaluate student's actual ability to use the fundamentals of knowledge and to meet new unknown situations as demonstrated by the students' interaction with the instructors and instructor-in-charge and aggregated in the project report. The instructor-in-charge may assign specific hours for formal brain-storming sessions.

Management

MGTS F211 Principles of Management 3 0 3

Fundamental concepts of management - planning; organizing; staffing; directing and controlling; production, financial, personnel, legal and marketing functions; accounting and budgeting, balance sheets.

MGTS F311 Marketing 3 0 3

Marketing Management: An Introduction; Strategic Marketing and marketing Plan; The Marketing Environment; Market research; Building Customer satisfaction, Value and retention; Analyzing Consumer Markets; Industrial buyer behaviour; Segmenting and Targeting the Market; Analyzing Competition; Creating and managing brand equity; Positioning and differentiating the market offering; Product strategy; Services marketing; Pricing strategies and programmes; Designing and Managing Marketing channels; Integrated marketing communications; Marketing mix and strategy.

MGTS F313 Product and Brand Management 3 0 3

Scope of product Policy Decisions; Product-Market strategy; Product Life Cycle and Strategy; Managing Product Deletion; Product Associations; Branding including aspects of brand name selection; Brand Equity and its utilization for marketing decision making; Brand Extension: use for brand names for launching new products; Managing new product development: New product development process; Idea Generation and Screening; Concept Development and Evaluation; Product Design and Testing; Market planning; Testing the market plan; Marketing research process; Adoption and Diffusion of products; Organizing for a new and existing product.

MGTS F314 Essentials of Financial Management 3 0 3

Overview and introduction to financial management, Basic principles of financial management, Introduction to financial markets, Key financial statements, Financial statements analysis (horizontal, vertical, and ratio analysis), Time value of money and its applications, Bond valuation, Stock valuation, Introduction to risk and return, Types of risk, Introduction to Risk Management, Break even analysis, Cost of capital (basic concepts, relevance and importance to business decisions), CAPM model, Weighted Aver-

age cost of capital (WACC), Capital budgeting, Financial forecasting, Sensitivity Analysis, Scenario Analysis, Working capital management, Capital structure and dividend policy, Introduction to corporate governance, Introduction to derivatives, international finance.

MGTS F315 Foundations of Business Analytics 3 0 3

Introduction to Business Analytics, Analytics on Spreadsheet, Visualizing and Exploring Data, Descriptive Statistical Measures, Probability Distribution and Data Modelling, Sampling and Estimation, Statistical Inference, Trending and Regression Analysis, Forecasting Techniques, Introduction to Data Mining, Spreadsheet Modelling and Analysis, Monte Carlo Simulation and Risk Analysis, Linear Optimization, Integer Optimization, Decision Analysis.

MGTS F316 Managerial and Leadership Skills 3 0 3

Role of a Manager and a Leader; Ethics and Integrity; Trust & Commitment; Emotional Intelligence; Networking Skills; Decision Making; Vision and setting goals; Team Building; Delegation; Basics of Supervision; Communication Skills - Effect speaking, Listening, Presentation, Persuasion; How to Handle Meetings; Negotiation Skills & Techniques; Interviewing Skills; Process of Induction; Training and Development; Mentoring & Coaching, How to Appraise Employees; Managing Change; Grievance Handling; Time management; Work Life Balance; Stress Management.

MGTS F351 Organisational Behaviour 3 0 3

A new perspective of management; conceptual model of organization behavior; the individual processes- personality, work attitude, perception, attribution, motivation, learning and reinforcement, work stress and stress management; the dynamics of organizational behavior- group dynamics, power & politics, conflict & negotiation, leadership process & styles, communication; the organizational processes- decision making, job design; organizational theory and design, organizational culture, managing cultural diversity; organizational change & development.

MGTS F433 Advertising and Sales Promotion 3 0 3

The communication process and models of persuasive communication; advertising research; advertising campaign components; advertising campaign planning; advertising/media scene; media concepts; media planning & strategy; advertising campaign planning, execution and evaluation; advertising agencies; sales promotion types and techniques; sales promotion strategy; measuring the effectiveness of the promotional program; regulations of advertising and promotion; Extending marketing communication to social communication, personal selling, international advertising, interactive advertising, advertising laws, social, ethical and moral issues.

MGTS G511 Advanced Marketing Theories and Advertisement 5

Strategic planning, theory and methods with emphasis on customer, competitor industry and environmental analysis and its application to strategy development and choice. Marketing communication through advertising and related mass media and promotion campaigns and its influence on market and other organisation. Globalisation and marketing aspects.

MGTS G513 Public Programme Evaluation 5

Value judgements & public choice, social welfare-Pareto Welfare Economics; market system, income distribution and government & the market. social cost benefit Analysis (SCBA): SCBA and public sector investment planning, efficiency pricing & the rational of new methodology, problems of pricing comparative advantage, social pricing; the application SCBA: economic pricing of factor of production, social pricing, distribution & public sector; management values of public sector undertakings.

MGTS G521 Business Policy-Structure and Organisation 5

Frame-work of business dynamics; missions; objective and goals; social aspects of business policy; environmental analysis; the dynamic setting of business policy; internal analysis of resources -

strength and weaknesses; strategic planning choice, implementation and evaluation; functional policies; orientation in special cases - MNC's high-tech companies, non-profit organisations etc.

MGTS G531 Recent Advances in Organisation Behaviour Theory 5

Emerging challenges of human resource management- a futuristic perspective; unified global theory of management; empowerment; employee ship; entrepreneurship; organisation diagnosis and development; social system and organisational culture-both in the national and global context interpersonal and group dynamics; employee attitudes; leadership and decision making; motivating employees; quality of work life and socio - technical systems; dealing with subordinates, boss, peers, problem employees.

MGTS G541 Management Information and Decision Support Systems 5

Data & information; characteristics of information; components of management information systems; information flows; design and maintenance of management information systems; decision support systems.

MGTS G551 Frontiers in Financial Management 5

MGTS G561 Institutional Finance and Project Appraisal 5

Mobilization of funds internally, externally, financial institutions and international financial institutions, financial and monetary framework of international financial management, foreign exchange markets and negotiations, project definition, preparation of feasibility assessment and selection, project reporting, conventional project appraisal - limitations, towards a new framework.

Public Health

MPH G510 Biostatistics & Computers in Public Health 5

Introduction to data classification, analysis and probability; statistical inference – estimation and hypothesis testing; linear regression and correlation; design of experiments; analysis of variance; non parametric procedures & tests; statistical quality control; experimental design in clinical trials and validation; basic techniques in optimization.

Introduction to computer and its component, operating systems; principles and use of standard software packages having application in drug design, development, analysis, etc; principles of software creation; processing concepts, flow charting and algorithms, programming constructs, programming languages, program development sequence; information systems; need, significance concepts, their analysis, design and implementation; software life cycle with special reference to software planning and maintenance.

MPH G512 Environmental & Occupational Health 4

Introduction to environmental health and its importance; pollution from water, air, automobile, chemicals used in agricultural sector and their implication on health and environment; techniques for studying, monitoring and controlling pollution; handling and disposal of domestic industrial and bio-medical refuse, incineration of waste materials; methods of vector control; effect of low frequency electromagnetic radiation and nuclear radiation on public health, occupational health hazards; disaster management.

MPH G513 Public Health & Diseases 4

Tropical diseases – their geography, identification, treatment methods, medicines, design of standard protocols and immunization processes including planning and execution; infections due to ticks and mites; bacterial, parasitic and viral infections- types and their classification, host-parasite relationships, their mode of proliferation, mechanisms of infestation, carriers, preventive methods and processes; understanding the public health problems related TB, AIDS, leprosy, GI infections and other communicable diseases.

MPH G515 Communication in Health Care 4

Role and importance of communication; effectiveness in oral and written communication; technical reports; technical proposals; re-

search papers, interpersonal communication; business correspondence; use of modern communication aids and mass media; behavioral change communication; design, management & evaluation of IEC.

MPH G521 Health Care Management 4

Basis of organizational culture and management techniques for efficient administration of health delivery; general principles of HR, materials and operation management; understanding the organizational culture that exists in public, private and non-Govt. sector agencies; management information system.

MPH G522 Preventive Nutrition & Health Promotion 4

Basic concepts; nutritional requirements of essential nutrients, proteins, fats, carbohydrates, vitamins and minerals; balanced diet; nutritional problems in public health; nutritional factors in selected diseases; assessment of nutritional status; nutritional surveillance; mal-nutrition; special nutritional programme.

MPH G523 Epidemic & Disaster Management 4

Disaster management; impact and response; relief phase; disaster mitigation in health sector; disaster preparedness; policy development; man-made disasters; international agencies providing health based humanitarian assistance; and strategies for disaster management.

MPH G531 Health Economics & Financial Management 4

Concepts & methods of economic analysis related to health system; organization and policy; demand and supply of scarce resource for health care; health financing & population coverage; determinants of cost & utilization; health insurance; cost-benefit analysis; costing for decision making; fundamentals of accounting; financial statement analysis; budget process & budgetary control; capital investment decision.

MPH G535 Family & Community Health Measures 4

Community-level indicators (CLI) measure aspects of the physical, legal, social and economic environment that reflect and are likely to influence the attitudes and behavior of individuals and community members. They also measure an important step in community-based health promotion interventions. Topics like, rural health services and health sector reforms from community perspective.

MPH G537 Law & Ethics in Public Health 3

Various Acts/ legislations/ rules pertaining to public health and related fields like, drug & pharmaceuticals, medical practice, PNDT, CPCSEA, IHEC, Regulations related to waste disposal.

MPH G538 Telemedicine 3

Advancing the use of digital telecommunications technology for the purpose of improving health care delivery to rural and underserved remote populations. Service areas include clinical services, educational programs, and research and development to provide high quality specialty care in participating rural communities and evaluation of the clinical utility and cost impact of telemedicine. Topic included will be Introduction to Telemedicine, Telehealth, Telemedicine Services, Telemedicine Systems and Telecommunications, Telemedicine Applications, Benefits and Drawbacks of Telemedicine, Information Sources, Advancing Telemedicine, etc.

MPH G539 Inter-sectoral co-ordination in Health Services 3

Roles of public, private, government, non-government sectors in providing health services, Public works department, Sanitation, Waste disposal and management, Water and air pollution monitoring and control, Deforestation, Urbanization and rural development, Employment and occupational health hazards, Training of administrators and enforcement agency staff, Public awareness programs, etc.

MPH G540 Role of Voluntary bodies/ NGO's in Public Health 3

Civil society organizations, Red Cross, Red Crescent movement and nongovernmental organizations in fund raising, international

and local humanitarian responses, partnerships and collaborations with civil society, Operations in remote areas and marginalized groups; Role of indigenous voluntary bodies, Functioning of NGOs, WHO in preparedness and response efforts and Needs-based deployment of available resources, Effective health services coordination, etc.

MPH G613 Health Systems and Society 2

Introduction to health systems; functions of health systems; managing health systems; problems of health systems management; Major environmental health problems including quality of water, waste disposal food production and processing, vector control etc. Air pollution and its controlling, Hazards of radiation, municipal and other wastes, Occupational health hazards.

MPH G661 Research Methodology I 5

Course description is same as given under SKILL G661.

MPH G665 Hospital Operations Management 3

Operation Management aspects connected with outpatient ward, casualty, operation theatres, diagnostic laboratories, pathology laboratories, pharmacy diet and nutrition, blood bank, laundry, medical records, security, scheduling and deployment of doctors, nurses and other staff, accounts among others. The course will involve on site visits in a hospital, discussions and presentations on the practical aspects of hospital operations management.

MPH G681 Strategic Management 3

Concepts of Strategic Planning; Environment Analysis; Internal and External; Resource Analysis; Organizational Structure and Linkage with Strategies, Formulation, Implementation and Control of Strategic Plan; Communicating Strategic Plan; Case studies.

MPH G692 Epidemiology 2

Introduction to the principles and methods of epidemiology. Epidemiology of some illustrative infectious diseases (of bacterial, rickettsial and viral origins), sexually transmitted diseases, chronic diseases such as cancer, cardiovascular diseases, neurological disorders etc. Use of biostatistics in epidemiology.

Manufacturing Systems Engineering

MSE G511 Mechatronics 3 2 5

Concepts of measurement of electrical and non-electrical parameters; displacement, force, pressure etc. and related signal conditioning techniques, drives and actuators, concepts of microprocessors/ microcontrollers architecture and programming, memory and I/O interfacing. System design concepts through case studies.

MSE G512 Manufacturing Planning and Control 4

Introduction, operations and manufacturing strategy for competitive advantage, product design and planning, forecasting product demand, facilities location, process selection and design, capacity planning, layout of facilities, job design and work measurement, aggregate planning, master manufacturing schedules, material requirements planning for dependent demand, short-term schedules and shop floor control, independent demand inventory systems, logistics and supply chain management, just-in-time systems, maintenance and reliability, quality management, managing projects, strategies for manufacturing excellence.

MSE G513 Maintenance Engineering 3 1 4

Introduction, maintenance systems, methods and tools of maintenance analysis, reliability and safety, maintainability, supportability, design for maintenance, maintenance integration, computerized maintenance management systems, TPM, world-class maintenance systems, and maintenance effectiveness and performance evaluation.

MSE G514 Leadership and Managing Change 3 1 4

Individuals as leaders, team leadership and organizational leadership. Introduction to managing change, management of change : organisational structure, culture, recruitment, performance management, human resource development, reward management,

employee relations and involvement, downsizing, and evaluating and promoting.

MSE G521 World-Class Manufacturing 3 2 5

The world-class manufacturing challenge, developing a world-class manufacturing strategy, just-in-time, total quality, total employee involvement, world-class information systems, managing the change, methods and procedures; improved brainstorming methods, using the check-total quality - the first steps, getting people involved, monitoring world-class performance.

MSE G531 Concurrent Engineering 3 2 5

Introduction of concurrent engineering and need, concurrent engineering tools, advances in design and manufacturing engineering, design for manufacture, design for assembly, rapid prototyping, simulation, concurrent approaches to design, manufacturing and other aspects of engineering.

Materials Science and Technology

MST F331 Materials Characterization 3 1 4

Thermal properties of Materials and Characterization, Electrical Characterization: Temperature dependent DC conductivity in materials, impedance spectroscopy, Characterization instruments like impedance analyzer, Optical Characterization: UV-Visible spectroscopy, FTIR spectroscopy, optical microscopy, Confocal microscopy, Mechanical Characterization: Time dependent and time independent mechanical behavior of materials, Dynamic Mechanical Analysis, Instruments: Universal testing machine, Fatigue machine, Izod and Charpy impact testers, Hardness indenters, Abrasion tester, Physical Characterization: Microstructure Characterization, Characterization instruments: SEM, TEM, X-ray diffractometer, AFM, Rheological Characterization: Linear and non-linear visco-elastic behavior of materials. Magnetic Characterization: Basics of diamagnetism, ferromagnetism and paramagnetism, anti ferromagnetism and ferrimagnetism, hysteresis and anisotropy, AC susceptibility and SQUID magnetometer.

MST F332 Materials Processing 3 0 3

Processing of metals: electrometallurgy, hydrometallurgy, pyrometallurgy, extraction, and refining, Powder processing of metals and ceramics: Powder handling, compaction and forming techniques. Drying, burnout, densification, sintering, and grain growth in powder compacts. Crystal growth, epitaxial growth, Deposition of thin films – Plasma Laser deposition, metal organic chemical vapour deposition, Production of carbon-based materials: Controlled pyrolysis, electro-spinning.

Processing of plastics and fiber reinforced plastics: Processing by using techniques such as extrusion, injection molding, compression molding, SMC, pultrusion and filament winding.

MST F333 Introduction to Biomaterials 3 0 3

Proteins, polysaccharides, oils and fats, fibers and biopolymers, structure and characterization of biomaterials, isolation and processing of biomaterials, development of polymers and composites from biomaterials, structure-property relationships (thermal, mechanical, biocompatibility, biodegradation etc.). Value-added products developed by using biomaterials, adhesives, bioplastics, composites for insulation and construction applications, biomedical applications such as, dental implants, sutures etc.,

MST F334 Materials for Catalytic applications 3 0 3

Classification of different industrial catalysis technology; Classification of solid catalysts; Synthesis of bulk and nanomaterials; Chemical properties of energy-relevant materials environmental catalytic materials at the nanoscale.; Metals and metallic alloys supported on oxide-based catalytic materials; Metal-support interaction; Structure sensitivity of catalytic reactions; Reaction mechanisms in catalysis on metal supported catalysts; Porous materials for catalyst supports; Oxide non-stoichiometry - structural defects; Semiconductor character - photocatalysts; Acidic and Basic oxide catalysts; Lewis and Brønsted acidity in oxides; Hydrotalcites - precursors for base oxides; Sulfide based catalysts.

MST F335 Coating and Thin film technology 3 0 3

Coating composition, pigments, binders, solvents, additives, Industrial process of making coatings, Rheology and mechanical properties of coatings, coatings in building and automotive sector, Introduction and formation of thin films by processes such as CVD, PVD, electrochemical deposition, thermal sprays, etc. Characterization of thin films such as coating hardness, thickness, assessment of friction & wear, roughness using nano-scale tests. Applications such as in defense, solar energy, consumer goods and implant materials.

MST F336 Glass Technology 3 0 3

Introduction to glass, glass transition, principles of glass formation and molecular structure of glass. Structural basis for glass formation. Characterization of properties of Glass. Glass making: Raw materials and mixing methods, batch wetting and compaction techniques. Glass batch melting reactions and principles. Glass technology and commercial glasses: Press and blow, Individual selection machines, molds, and container design. Surface treatments and chemical durability. Flat glass forming and fabrication. Fabrication processes: chemical strengthening, annealing, tempering, and laminating. Strengthening of glass by physical and chemical means. Gorilla glass. Fiber glass manufacturing methods and products for application in insulation, filtration, polymer reinforcement and textiles.

MST F337 Materials for Energy Applications 3 0 3

Overview of conventional and non-conventional energy resources, Silicon based Photovoltaic Solar cells, Photovoltaic thin films, Lightweight composites for wind turbine blades, Metals and ceramics used in thermal power plants, Ceramics for Energy storage and conversion, Ceramics and Composites for Nuclear energy, Photoelectrochemical Cells for hydrogen generation, Functional materials for Hydrogen storage, Functional Materials for fuel cells, Membrane electrode assemblies for fuel cells including DMFC's, Novel materials for Solid oxide fuel cells (SOFC) systems.

MST F338 Metals and Alloys 3 0 3

Introduction, classification of Ferrous metals, Non-ferrous metals such as Titanium, Aluminium, Magnesium, Copper and their alloys, Structure-property relationship, Phase diagrams and Phase kinetics, processing and applications of metals and alloys, degradation of metals, Applications in transportation, chemical and medical sectors.

MST F339 Polymer Materials 3 0 3

Polymerization techniques; classification of polymers; mechanism and kinetics of formation of polymers; Theoretical and experimental techniques for determination of different types of molecular weights and molecular weight distributions; polymer solution viscosity; melting and glass transitions, rheology; polymerization techniques used in industry, polymer solution thermodynamics; viscoelastic behaviour; degradation and stability; polymer processing and applications. Engineering thermoplastics, additives, blends, polymer composites and Biopolymers. Applications in automobile, biomedical and electronic and other industries.

MST G511 Nondestructive Testing Techniques 3 2 5

Ultrasonic testing, X-radiography, eddycurrent testing, magnetic methods of crack detection, liquid penetrant inspection, acoustic emission and acousto-ultrasonic testing techniques.

MST G512 Ceramics Technology 3 2 5

Ceramic raw materials, their beneficiation and characterisations; crystal structure of important ceramic systems and structural defects; various types of ceramics; white wares, glasses, refractories, cements, abrasives, glass-ceramic, ceramic coatings, electronic ceramics; fabrication processes; grinding, pressing, slip casting, drying, sintering, glass blowing; development of ceramic microstructures; properties of ceramic materials; mechanical, thermal, electrical, optical, magnetic and chemical; ceramic composites, cermets.

MST G521 Materials Characterization Techniques 3 2 5

Materials characterisation - definition; importance and application with case studies, principles and general methods of compositional, structural and defect characterisation, techniques of X-ray, electron and neutron diffraction, EDAX, thermal methods - DTA, TGA, DSC. TMA and DMA; microscopy-optical, electron (TEM & SEM) and spectroscopy -UV, visible, IR and Raman spectroscopy, ESCA and Auger spectroscopy, SIMS resonance method-NMR, ESR, Mossbauer techniques, particle size analysis, electrical and magnetic characterization techniques.

MST G522 Advanced Composites 3 2 5

Definition of composite materials; classification; particulates and dispersion hardened composites, continuous and discontinuous fibre reinforced composites, metal-matrix composites, carbon-carbon composites, molecular composites, micro and multilayer composites, theory of reinforcement; reinforcement by continuous and discontinuous fibres, concept of microfibril; effect of orientation and adhesion; mechanical behaviour of composites, stress-strain relationship, strength, fracture toughness and fatigue; properties of fibre reinforcement and production technology of composites.

MST G531 Experimental Stress Analysis Techniques 3 2 5

Strain gauges, photoelasticity, brittle lacquer, three dimensional photoelasticity, Moire methods.

MST G532 Electronic Materials 3 2 5

Electrical conduction in glasses and ceramics, non-stoichiometry and valence controlled conduction, ceramic heating elements, fast ion conductors, superconducting materials and devices, dielectric ceramics, ceramics in micro electronics, voltage dependent resistors, positive and negative temperature coefficient resistors. Piezo electric, pyroelectric, ferroelectric and electrooptic ceramic materials and devices, ceramic sensors, magnetic and magneto-optic ceramic devices, ceramics for microwave applications, luminescent and photoconducting ceramics, light transmitting filters, IR transmitting glass, optical fibre technology.

Music

MUSIC N103T Indian Classical Music (Vocal) I	3*
MUSIC N104T Indian Classical Music (Vocal) II	3*
MUSIC N203T Indian Classical Music (Vocal) III	3*
MUSIC N204T Indian Classical Music (Vocal) IV	3*
MUSIC N111T Hindi Classical Music (Instrumental) I	3*
MUSIC N112T Hindi Classical Music (Instrumental) II	3*
MUSIC N113T Indian Classical Music (Instrumental) I	3*
MUSIC N114T Indian Classical Music (Instrumental) II	3*
MUSIC N213T Indian Classical Music (Instrumental) III	3*
MUSIC N214T Indian Classical Music (Instrumental) IV	3*

The eight courses given above – four in vocal and four in instrumental - are designed to give theoretical and practical knowledge of Indian Classical Music in Hindustani or Carnatic style.

In the Hindustani series, the student will be introduced to the Hindustani system, *swaragyan*, structure of *Raags* and *Taals*, the ten *Thaats*, and practice in performing selected *raags* through compositions with elaborations.

For the Carnatic style series, the syllabus includes basic *Swara gyaana*, structure of *Raagas* and *Taalas*, renderings of graded compositions in the form of *Geetam*, *Swarajati*, *Varnam* and *Keertanam*, introduction to the *Melakarta* and *JanyaRaaga* system with reference to the seventy two *Melakartas*, performance practice including compositions and elaborations.

These courses are not available for fulfilling the requirements of any programme in the institute and can be taken only as audit courses.

MUSIC N105T Western Classical Music I 3***MUSIC N106T Western Classical Music II 3*****MUSIC N205T Western Classical Music III 3*****MUSIC N206T Western Classical Music IV 3***

The above four courses are designed to introduce and train the student in notation, rhythmic concepts and practice of western classical music.

The beginning level will develop the skills of reading and writing notations, supported by singing exercises. The objective of the theory part is to impart the required skills for reading music while either playing an instrument or plain vocal. The student will be trained further in keyboard or violin practice.

At the advanced level, the student will be trained in more complex notations, rhythms, concept of Harmony melody etc., and composing rhythms and melodies. Training syllabus and examination tests will be based on that of the Associated Board of the Royal Schools of Music, London, and/or the Trinity-Guildhall board of music examinations.

(These courses are not available for fulfilling the requirements of any programme in the institute and can be taken only on audit).

MUSIC N303T Advanced Indian Music Practice (Vocal) 0**MUSIC N313T Advanced Indian Music Practice (Instrumental) 0**

These courses are designed to allow facilities for practice with minimum supervision for students who have satisfactorily completed MUSIC N204T or MUSIC N214T respectively. These courses carry zero units. A student who has met the prerequisite can take these courses as audit courses as many times as he needs.

Pharmacy**PHA F211 Pharmaceutical Analysis 2 1 3**

Basic techniques of pharmaceutical analysis, data handling and analysis, sources of error in analysis. The analytical methods would comprise of various titrimetric methods, such as acid-base, complexometric, non-aqueous, oxidation-reduction, precipitation, conductometric; physical and instrumental analysis such as gravimetric, polarography, nephelometry, amperometry, turbidometry, potentiometry; chromatographic separations such as TLC, column, ion-exchange,

extraction methods such as gel-filtration, fractionation processes, analysis of metallic and non-metallic elements; water content, as well as evaluation of drug constituents in various pharmaceutical preparation.

PHA F212 Dispensing Pharmacy 2 1 3

Prescriptions, principles involved in the dispensing of prescriptions; physical, chemical and therapeutic incompatibilities involved and their remedy in such prescriptions; techniques involved in dispensing of mixtures. ENT preparations, parenteral products, radiopharmaceuticals, etc.

PHA F213 Microbiology 2 1 3

Introduction and classification of microbes; structure and physiology of microbial cell; infection and immunity; host parasite relationship; microbiology of milk, air, water and food; physical and chemical methods of controlling microbes; experiments for isolation, cultivation, physiological and biochemical characterization of microbes.

PHA F214 Anatomy Physiology & Hygiene 2 1 3

Anatomical study of the important organs of human body; physiology of various functional systems of human body; general principles of personal and community hygiene and prevention of communicable diseases.

PHA F215 Introduction to Molecular Biology & Immunology 3 0 3

Basic aspects of cell and molecular biology, DNA replication, transcription, translation and control mechanisms of protein synthesis. Post transcriptional modifications and post-translational modifications, DNA-protein interactions and regulation of gene expression. Cell signalling. Regulation of cell cycle. Basic aspects of immune system, cell-mediated and humoral immunity.

PHA F216 Pharmaceutical Formulations I 2 1 3

Prescriptions; understanding commonly used terminologies in a prescription; principles involved in the dispensing of prescriptions; labelling; posology; pharmaceutical calculations; physical, chemical and therapeutic incompatibilities; types of dosage forms; additives employed in dispensed preparations; techniques involved in preparation, packaging, quality control and stability of various preparations including liquid preparations (solutions, emulsion, suspensions, mixtures, elixirs, etc.), semi-solid preparations (creams, ointments, pastes, etc.), suppositories, powders, sterile liquids like ophthalmic drops and parenteral solutions etc.

PHA F217 Pharmaceutical Microbiology 2 1 3

Introduction and classification of microbes; structure and physiology of microbial cell; bacterial growth and nutritional requirement; isolation and preservation methods for pure cultures; sterilization techniques and its evaluation; microbial genomics and genetic exchange; infection and immunity; microbial diseases; antimicrobial drugs; production of antibiotics and vaccines etc.

PHA F241 Pharmaceutical Chemistry 2 1 3

This course deals with study of important classes of organic compounds such as alcohols, ethers, esters, aldehydes etc and their reactions. The mechanisms for various reactions will also be dealt with to comprehensively cover the basics of chemical reactions. Some important five and six member heterocycles with their reactions will also be part of the course. This course also emphasizes the use of inorganic compounds in pharmacy.

PHA F242 Biological Chemistry 2 1 3

This course focuses upon the physiological and medical significance of important biomolecules along with their use as drug targets. The course also elaborates the role of vitamins as prosthetic groups of enzymes and enzyme kinetics and regulation. The course deals with the understanding of chemical structures, biochemical reactions metabolic pathways related to carbohydrates, lipids, nucleic acids and protein synthesis and diseases arising from defects in these pathways.

PHA F243 Industrial Pharmacy 2 1 3

Pharmaceutical processes and equipments commonly used in pharmaceutical industries; drug extraction and clarification; mixing and granulation; pharmaceutical preparations such as aromatic waters, spirits, syrups, elixirs, lotions, liniments, official solutions, etc.; galenic products like infusions, decoctions, tinctures, extracts, etc, glandular preparations and blood plasma substitutes.

PHA F244 Physical Pharmacy 2 1 3

Preformulation characterization including solid state pharmaceuticals, crystallinity, solubility, micromeritics, drug stability and compatibility, reaction kinetics, rheology, interfacial phenomenon, principles of diffusion and dissolution. Different types of colloidal systems and their properties and complexation.

PHA F266 Study Project 3

These courses include projects which are oriented towards readings from published literature or books about new frontiers of development or analysis of available database. These courses are normally available to students in second or higher levels. These courses must coterminate with project reports.

PHA F311 Pharmacology I 2 1 3

This course is intended to impart the knowledge regarding the sources, routes of drug administration, pharmacokinetics (ADME) and pharmacodynamics (mechanism of action) of various drugs.

This course is also intended to impart the knowledge regarding the concepts of action of drugs on various systems of the human body including ANS, SNS and CNS. The course also deals with therapeutic uses, side effects and contraindications of the drugs, which are commonly prescribed for the treatment of various disease conditions.

PHA F312 Medicinal Chemistry I 2 1 3

Study of important classes of drugs predominantly acting on CNS, ANS, SNS. Structure, properties, therapeutic and pharmaceutical importance and the uses of drug molecules both of natural and synthetic origin. Study of physicochemical properties, mechanism of action, S.A.R. and metabolism, factors affecting metabolism of drugs. Special emphasis on important topics such as Cholinergic drugs, Adrenergic drugs, Local anaesthetics and general anaesthetics, Sedatives, hypnotics and anti-anxiety drugs, Antiepileptics, Antihistamines, NSAIDs, Thyroid and Antithyroid Drugs, Drugs for Erectile Dysfunction.

PHA F313 Instrumental Methods of Analysis 2 1 4

Principle, configuration, applications of instruments like mass spectrophotometer, NMR, UV, IR, X-ray apparatus, atomic absorption/emission spectrophotometer, chromatographic techniques such as gas, HPLC, HPTLC, ion exchange, gel, affinity, high voltage electrophoresis, DTA, DSC, TGA, etc.

The course is specially designed for students in the first degree majoring in experimental sciences and would require groups of students to work with the above instruments in order to appreciate the potentiality of such modern instrumental methods of analysis.

PHA F314 Pharmaceutical Formulations and Biopharmaceutics 2 1 3

Physical, chemical and biopharmaceutical considerations in formulations, absorption, distribution and elimination of drugs; pharmaceutical additives; formulation and stability aspects of solid dosage forms, semi-solid dosage forms and liquids dosage forms; sustained release medication; aerosol products and packaging.

PHA F315 Pharmaceutical Formulations II 2 1 3

Physical, chemical and biopharmaceutical considerations in formulations, absorption, distribution and elimination of drugs; pharmaceutical additives; formulation, manufacturing, packaging, quality control and stability of solid dosage forms, semi-solid dosage forms, liquids dosage forms, and sterile preparations including parenteral suspensions, emulsions, depot formulations; microencapsulation and controlled release formulations; targeted drug delivery systems; multi-unit particulate systems; transdermal, gastroretentive, and nasopulmonary drug delivery systems; aerosol products and packaging.

Pre-requisite:

PHA F216: Pharmaceutical Formulations I

PHA F316 Pharmaceutical Regulatory Science 3 0 3

Fundamental knowledge on the regulatory requirements for approval of new drugs, and drug products in regulated markets of India & other countries like US, EU, Japan, Australia, UK, etc. Regulatory documentation requirements and registration procedures for marketing the drug products in these countries.

PHA F317 Safety Pharmacology and Toxicology 3 0 3

Introduction to toxicological principles, their role in new drug design and development, toxicokinetics, various influencers that give rise to mutagenesis, teratogenesis, carcinogenesis including developmental toxicity, organ toxicity with special reference to hepatic, renal, cardiovascular and neurological systems would be covered. ICH, OECD guidelines on toxicity studies, their importance in pre-clinical drug development.

Pre-requisite:

PHA F311 : Pharmacology I

PHA F341 Pharmacology II 2 1 3

This course is intended to impart the knowledge regarding the concepts of actions of drugs on various systems of the human

body including cardiovascular system, urinogenital system, respiratory system, gastrointestinal and endocrine system etc. The course also imparts the knowledge regarding the mechanisms of action of various antimicrobial agents in the treatment and prevention of various diseases caused by the bacteria, fungi viruses and parasites. The course also deals with the drug-drug interactions, therapeutic uses, side effects and contraindications of the drugs, which are commonly prescribed for the treatment of various disease conditions.

PHA F342 Medicinal Chemistry II 2 1 3

This course deals with the study of important classes of drugs. Various aspects like structure, properties, therapeutic and pharmaceutical importance, mechanism of action, S.A.R. and metabolism of drugs and the uses of drug molecules both of natural and synthetic origin will be covered. Special emphasis will be given to topics such as Anti-hypertensive drugs, Anti-diabetic drugs, Steroids and steroidal drugs, Antimalarial drugs, Anticancer agents, Antiviral agents, Antiprotozoals, Anthelmintics, etc. Concepts of QSAR approach to drug design, molecular modelling, and combinatorial chemistry will also be discussed in addition. Principles of Toxicology.

PHA F343 Forensic Pharmacy 2 - 2

A study of the professional pharmacist's relation to the public and to other professions; a critical survey of statutory regulations governing the practice of pharmacy and drug industry in all its aspects; history and ethics of the profession of pharmacy.

PHA F344 Natural Drugs 2 1 3

The course imparts a knowledge of the crude drugs of natural origin used in pharmaceutical and medical practice. Study will include the different systems of classifications of crude drugs; cell contents; general principles of cultivation, collection, drying, storage and commerce of natural products of current medical and pharmaceutical importance; their morphological and microscopical study: use and knowledge of common substitutes and adulterants.

PHA F366 Lab Project 3

PHA F367 Lab Project 3

These courses include projects involving laboratory investigation or laboratory development in the students discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

PHA F376 Design Project 3

PHA F377 Design Project 3

These courses are intended to impart training in design of product/ process or other artifact to the students in the discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

PHA F413 Pharmaceutical Management and Quality Control 3 0 3

Concepts of Pharmaceutical management, Managing of pharmaceutical industry, planning, layouts, designs, current good manufacturing practices, pharmaceutical process validation, documentation, pilot plant scale up technique optimization, pharmaceutical marketing, quality aspects and quality control, managing hospital pharmacy and its importance.

PHA F414 Biopharmaceutics 3 0 3

Biopharmaceutics and Biopharmaceutical aspects of drug delivery covering absorptions, distribution, metabolism and elimination (ADME) characters of drugs. Compartment model, pharmacokinetics of drugs and their applications, bioavailability, bioequivalence and their studies, drug-drug interactions and other related matters.

PHA F415 Pathophysiology 3 0 3

Cellular pathology, inflammatory, genetic and immunological disorders, infectious diseases- their expression and cause, targets

for therapy, diseases of the organ systems, environmental and nutritional pathology.

PHA F416 Chemistry of Synthetic Drugs 3 0 3

Heterocyclic drugs; methods of heterocyclic drug synthesis; mechanisms of important heterocyclic compounds; mechanism based optimization of lead compounds on target sites; biological properties of heterocyclic drugs; synthesis of other special organic compounds of biological importance like polynuclear hydrocarbons etc. Introduction to Retrosynthetic approaches.

PHA F417 Pharmacoeconomics 3 0 3

Economic aspects of health care and its applications in the health sector are broadly emphasized. Cost-benefit, cost-effectiveness, cost-minimization, and cost-utility analyses to compare the different pharmaceutical products, drug therapy and treatments are focused. Economic concepts such as supply, demand, efficiency, equity, health policy, market failures, health insurance, pharmaceutical market, measurement of direct and indirect costs to a health care program, economic issues, pharmaceutical regulations, pricing policy and related topics will be covered.

PHA F418 Biopharmaceutics and Pharmacokinetics 3 0 3

Biopharmaceutics and Biopharmaceutical aspects of drug delivery covering absorptions, distribution, metabolism and elimination (ADME) characters of drugs. Compartment model, pharmacokinetics of drugs and their applications, bioavailability, bioequivalence and their studies, drug-drug interactions and other related matters.

PHA F419 Herbal Drug Technology 3 0 3

Operations in herbal drug industry, the quality of raw material, guidelines for quality of herbal drugs, classical ayurvedic and conventional formulations, nutraceuticals, herbal cosmetics, herbal excipients etc. Good Manufacturing Practices (GMP), patenting and regulatory issues of herbal drugs.

Pre-requisite:

PHA F344 : Natural Drugs

PHA F422 Cosmetic Science 2 1 3

Principles of formulation of typical cosmetic preparations such as cosmetic creams, powders, lipsticks, rouges, hair preparations, dentrifices, aerosol cosmetics, perfumes for cosmetic, their blending and mixing techniques. Some recent and new trends.

PHA F432 Hospital Pharmacy 3 0 3

Definition and function, location, organisation, staff, space, equipment. Pharmaceutical services, Medical stores, objectives, procedures for procurement and supplies, Distribution & control, inspection of stocks, Licensing procedures for stocking of alcohol, narcotics, Maintenance of records of stocks, issue and use. Pharmaceutical services for out - patient and in - patient department.

PHA F441 Biochemical Engineering 3 0 3

Principles of Chemical Engineering applied to Bioprocesses; Kinetic Models for growth, substrate utilization and product formation; Biological reaction kinetics and applied enzyme catalysis; immobilized biocatalysts; Bioreactor Design and Operation; Fermentation, Upstream & Downstream processing; Novel Bioreactor Configurations; Transport phenomena in Bioprocesses; Instrumentation and control; Bioprocess Optimization and Scale up; Industrial Protein Purification Techniques; Commercial Enzymes & Biopharmaceuticals; Bioprocess Patenting, Economics & Feasibility Studies.

PHA F442 Applied Pharmaceutical Chemistry 3 0 3

The course comprises of structure, reactions and synthesis of selected carbocyclic and heterocyclic ring systems. Their application for drug design, structure activity relationship, pharmacological action, methods of assay.

PHA F461 Phytochemistry 2 1 3

This course is intended to impart knowledge to the students in the isolation, characterization and chemistry of the natural products

derived from various sources, which are of pharmaceutical importance. Intriguing chemistry involved in their *in vivo* production and their importance as structural materials, biologically active molecules like toxins, hormones, life process substrates and drugs will be covered in this course, the evaluation of these substances using qualitative and quantitative methods will also be covered; special emphasis will be given to newer techniques in the biogenesis of these molecules.

PHA F491 Special Projects

3

This is an unstructured open-ended course where under the overall supervision of an instructor-in-charge, batches of students will be attached to different instructors. Each batch will work on a specific time-bound project which is of basic or peripheral concern of his discipline. Each student must submit a project report as a culmination of his endeavour and investigation. The instructor-in-charge will determine the choice of the project and also whether or not the project report is to be submitted jointly by a group or individually by a student. The course will aim to evaluate student's actual ability to use the fundamentals of knowledge and to meet new unknown situations as demonstrated by the students' interaction with the instructors and instructor-in-charge and aggregated in the project report. The instructor-in-charge may assign specific hours for formal brain-storming sessions.

PHA G510 Application of Statistics and Computer in 5 Pharmacy

to data classification, analysis and probability; statistical inference – estimation and hypothesis testing; linear regression and correlation; design of experiments; analysis of variance; non parametric procedures & tests; statistical quality control; experimental design in clinical trials and validation; basic techniques in optimization. Introduction to computer and its components; operating systems; principles and use of standard software packages having application in drug design, development, analysis, etc.; principles of software creation; processing concepts, flow charting and algorithms, programming constructs, programming languages, program development sequence; information systems: need, significance concepts, their analysis, design and implementation; software life cycle with special reference to software planning and maintenance.

PHA G511 Fermentation & Biotechnology

2 3 5

Industrial scale production by fermentation processes of antibiotics, vitamins, alcohol and other selected products, development, selection, isolation and preservation of mutants, media sterilisation, accretion and air sterilisation, continuous fermentation, recent advances in fermentation biotechnology, enzymes, their large scale extraction and purification, principles of immobilisation of enzymes and its applications.

PHA G512 Chemistry of Natural Drugs

3 1 4

Study of recent methods of phytochemical investigations with reference to alkaloids like rauwolfia, vinca, cantharanthus etc.; some selected steroids, terpenes & flavoring agents, their chemistry, structure activity relationship, pharmacological actions and synthetic routes.

PHA G521 Molecular Biology & Immunology

3 1 4

General principles governing the structures and functions of various molecules of the immune system, acquired immune responses, immunological tolerance, genetic control of immunity, hypersensitivity reactions, protein structure, functions, RNA and DNA cloning, principles of Genetic Engineering and its future in drug production.

PHA G522 Chemistry of Macromolecules

2 2 4

Physical, Chemical and Biological properties of biopolymers like proteins, nucleic acids, poly saccharides. Synthetic polymers, biomedical and pharmaceutical polymers with emphasis on recent development.

PHA G523 Total Quality Management and Regulatory (5*) Affairs

Quality control, quality assurance, total quality management, various parameters for achieving quality products, application of statistics in quality assurance, statistical process control, current good manufacturing practice (cGMP), introduction to process validation, drug regulatory affairs, clinical research protocols, new drug applications, intellectual property rights.

PHA G531 Disinfection and Sterilization

2 2 4

Theories and kinetics of the disinfection reaction, study of the principles involved in *in vivo* and *in vitro* evaluation of disinfectants and antiseptics, structure activity relationships of the representative groups of disinfectants, sterilisation, heat, ionizing and ultraviolet radiations, ultrasonic waves, filtration, gaseous sterilisation and cellular dessication methods, controls used and special problems involved.

PHA G532 Quality Assurance & Regulatory Affairs

3 2 5

Quality control, quality assurance, quality management, various parameters for achieving quality pharmaceutical products, application of statistics in quality assurance, reliability, current good manufacturing practice (cGMP) for pharmaceutical manufacturing, pharmaceutical process validation, drug regulatory affairs, clinical research protocols, new drug applications, drug product labeling.

PHA G533 Pharmaceutical Process Chemistry

4

Selection of routes, process optimization, Catalysis, plant layout and design, processes and flow sheets, Impurities - separation, synthesis and characterization, Good manufacturing practices in API (active pharmaceutical ingredients) industry, Industrial Safety, Occupational Health & Safety, Chiral separation.

PHA G534 Separation and Structure Elucidation Techniques

Advance separation methods for complex Natural, Semisynthetic and Synthetic New Chemical Entities (NCEs) using LC-MS, LC-MS-MS, LC-NMR, GC-MS, GC-MS-MS, CE-MS, Supercritical Fluid Chromatography. Structure elucidation of NCEs using 2D and 3D (1H and 13C) Nuclear Magnetic Resonance (NMR) spectroscopy and X-ray diffraction technique. Prediction of structures using Software tools.

PHA G535 Biomaterials

5

Introduction to biomaterials for pharmaceutical applications; polymeric biomaterials; Natural and synthetic polymers for drug delivery, regenerative medicine and nanomedicines; Polymer properties including crystallinity, glass transition, polymer degradation influencing pharmaceutical formulations; biocompatibility; biodegradation; *in-vitro* and *in-vivo* assessment of polymer toxicity.

PHA G536 Cosmetics and Cosmeceuticals

3 2 5

Fundamental concepts required in the field of cosmetics and cosmeceuticals, Biological aspects of cleansing and care required for skin, eye, lips, scalp, hair, nail etc. along with suitable agents/ingredients required for the same, Various aspects of the nature of cosmetic products and consumers' demand with respect to quality and elegance, Regulatory and safety guidelines catering cosmetic products, misbranded and spurious products, Special purpose cosmeceutical products, herbal cosmetics etc.

PHA G537 Parenteral Product Development

5

Parenteral product & their types, products characteristics; Vehicle requirement for Parenteral Product manufacturing; Formulation & process consideration for development of parenteral products; Various aspects of unit operation in parenteral product manufacturing; Critical Quality attributes of Parenteral Product; Sterilization techniques for parenteral products; Key requirements for aseptic processing; Lyophilization techniques of stable product development; Regulatory consideration for safety assessment of Parenteral Products; Packaging requirement for Parenteral Drug Products; Regulatory perspective for complex injectable products development and filing.

PHA G538 Immunopharmacology**4**

The course will include an overview of the cell types and key mediators involved in the innate and adaptive immune responses, the use of antibody preparations and small molecule immunotherapeutics to target chronic inflammation, cancer, metabolic diseases, neurodegenerative diseases and autoimmunity in selected diseases. This course will explore the role of gut microbiota and regulation of immune response. The development of therapeutic anti-bodies and proteins will be discussed along with aspects of immunotoxicology.

PHA G539 Principles of Drug Discovery**4**

Concepts of cellular mechanisms and processes involving cell surface receptors, membrane-bound enzymes, protein kinases, proteases, integrins, transporters and channels that facilitate drug discovery, with special emphasis on non-communicable diseases such as neurological, neuropsychiatric diseases and disorders, metabolic disorders, cancer. siRNA, anti-sense oligonucleotides, transgenic animals in drug discovery, long non-coding RNA, emerging trends in receptor - drug trafficking

PHA G540 Modern Pharmaceutical Analytical Techniques**3 1 4**

Principles of sample preparation, method development for analysis and characterization of Active Pharmaceutical Ingredients (API) and formulations, using techniques such as High Performance Liquid chromatography (HPLC), biochromatography, size exclusion, affinity, chiral, fast protein chromatography (FPLC). Characterization of nanopharmaceuticals using Atomic Force Microscopy, Scanning Electron Microscopy, Transmission Electron Microscopy, Dynamic Light Scattering techniques. ¹H and ¹³C Nuclear Magnetic Resonance (NMR) spectroscopy in structural characterization, Mass Spectrometry and its applications, Elemental analysis, Optical, chiro-optical techniques in structure elucidation.

PHA G541 Computer Aided Drug Design**3 2 5**

3D structure and function of bio-molecules; targets of drugs and design principles; molecular modeling methodologies; cheminformatics, quantitative structure-activity relationships; chemical compound databases and search tools; interactive graphics in drug design; molecular surfaces and algorithm of automated docking of drugs into receptor sites; receptor mapping; introduction to molecular modeling and docking software.

PHA G542 Advanced Physical Pharmaceutics**3 2 5**

Preliminary evaluations and molecular optimization, Drug substance considerations including protein, peptide and biological products, Bulk characterization, Solubility analysis, Rheology and dispersed systems, Micrometrics and shape factor analysis, Compression and compaction, Principles of dissolution, Dissolution test design and release kinetics evaluation, Compatibility testing, Stability analysis and test design according to international standard, Rationale basis of formulation recommendation.

PHA G543 Clinical Research**5***

Fundamentals of clinical trials including design, conduct, analysis and interpretation, randomization and blinding methods, sample size determination, recruitment methods, choice of controls, ethical, regulatory and research clearance including GCP, trial requirements-multi-centric/collaborative and related operational issues, data collection, processing, protocol management and quality control issues, interim analysis and critical review of intervention and therapies, design and results, statistical techniques in analysis and interpretation of results, documentation and reporting, pharmacovigilance.

PHA G544 Advanced Pharmaceutical Chemistry**3 2 5**

Stereochemical aspects of drugs and biological molecules; effect of stereochemistry on drug action and isomerism in various drugs; rearrangements and name reactions useful in synthesis of bioactive molecules; example applications of rearrangements and name reactions in synthesis of existing drugs.

PHA G545 Intellectual property rights and Pharmaceuticals**3 0 3**

Key aspects of intellectual property law and their impact on Pharmaceutical industry; concept of property with respect to intellectual creativity; emerging debates, policy issues and law reforms related to IPR with respect to pharmaceuticals; Issues of Intellectual Property such as Patents, Copyright, Trademarks, and Design; rules and regulations of marketing and competition; Patent processing, infringement of patents, ethics and economic issues related to IPR;

PHA G546 Pharmaceutical Biostatistics**3 0 3**

Different types of data; methods for data collection; organization and summarization of data; probability distributions; descriptive measures (measures of central tendency and measures of dispersion); sampling and estimation of parameters (point estimates and interval estimates); tests of hypothesis using parametric (t-test and ANOVA) and various non-parametric tests; correlation and linear regression; determination of sample size for a study; estimating bio-equivalence of pharmaceutical products

PHA G547 Quality-by-Design in Pharmaceutical Product Development**3 2 5**

Principles and tools of Quality-by-Design (QbD) for pharmaceutical product development and manufacturing; essential elements of QbD approach including basic risk analysis techniques; constructing the quality target product profile (QTPP); identification of critical quality attributes (CQAs); critical process parameters (CPPs); design of experiments (DoE); identifying design space and control strategy; selection of critical factors using various screening designs; optimization of factors using various experimental designs; introduction to process analytical technologies (PAT)

PHA G548 Chemistry of Natural Drugs**3 2 5**

Study of recent methods of chemical investigations on bioactive secondary metabolites of plants, microbes and marine origin with reference to alkaloids, steroids, terpenes, phenyl propanoids (flavonoids, coumarins, stilbenes, lignans, etc.) their chemistry, structure elucidation, structure activity relationships and their synthesis.

PHA G611 Advanced Pharmacology**3 2 5**

Biochemical pharmacology and cellular basis for pharmacological functions, pharmacodynamics, organ systems pharmacology – gastro-intestinal, cardiovascular, renal and respiratory systems, metabolic disorders, recent developments in the treatment of infectious, communicable diseases – epidemics and pandemics and their impact on organ systems and health, neuropharmacology and psychotherapeutic agents, autotoxins and autoimmune disorders, free radical pharmacology and their role in degenerative disorders, introduction to ethnopharmacology, pharmacogenetics, Prosthetics as adjuncts, alternatives to therapy.

PHA G612 Pharmacokinetics & Clinical Pharmacy**3 2 5**

Introduction to pharmacokinetic modeling of drugs; Compartmental modelling including one compartmental and two compartmental models; Non-compartmental analysis (NCA); Bioequivalence and comparative bioavailability studies; Pharmacokinetic Pharmacodynamic modelling techniques, determination of order of absorption and absorption rate constant by Wagner-Nelson method; non-linear pharmacokinetics; Pharmacokinetic drug interactions; multi-dose pharmacokinetics of drugs following one compartmental model; Design of multi-dose regimen; Dosage regimen adjustment in renal impairment; Application of the pharmacokinetic principles for better therapeutic outcomes.

PHA G613 Pharmaceutical Biotechnology**3 2 5**

Molecular biology, immunology, recombinant DNA technology and principles of biochemical engineering. Application of biotechnology in diagnosis, therapeutics and production of products of fermentation. Bioinformatic tools required to store, analyze and use biological information for therapeutic utility, immense potentiality and application of decoding the human genome.

PHA G614 Clinical Pharmacy and Therapeutics 3 2 5

Basic concepts of Clinical pharmacy and its applications, analysis of patient data interpretation of clinical laboratory tests, drug information queries, their sources and interpretation of the information. Clinical pharmacokinetics, therapeutic drug monitoring, drug-drug interactions.

PHA G614 Clinical Pharmacy and Therapeutics 3 2 5

Basic concepts of Clinical pharmacy and its applications, analysis of patient data interpretation of clinical laboratory tests, drug information queries, their sources and interpretation of the information. Clinical pharmacokinetics, therapeutic drug monitoring, drug-drug interactions.

PHA G615 Pharmacy Practice : 2 5

Overview of health care systems, providing drug information, physical examination, diagnostic procedures, drug administration, selection of alternate therapies, clinical alert, nutrition and electrolyte therapy, documentation of pharmacy services, patient counseling, paediatric pharmacy practice, evaluation of drug related problems, environmental, and health care management.

PHA G616 Pharmaceutical Administration and Management 3 2 5

Technology innovation and creativity, new drugs and products planning, strategic considerations, project implementation, product development, production management and scale up, preparation of product literature and marketing strategy, IPR processes, human resource development, industrial relations, documentation, R & D management, ethical aspects.

PHA G617 Advanced Drug Delivery Systems 3 2 5

A study of physicochemical and biopharmaceutical factors involved in the design of novel drug delivery systems like mucosal, particulate systems for systemic delivery of bioactive molecules. Special considerations for delivery of protein, peptide and other biological products. In vitro and in vivo evaluation of novel drug delivery systems.

PHA G618 Retrosynthetic Analysis 3 2 5

Methods and techniques to transform target molecule to precursors, functional group, stereo-chemical, structural, transform based and topological strategies involving organic reactions, functional group inter-conversions, reconnection and disconnection approaches, acyclic, ring structure synthesis, rearrangement reactions pertaining to the synthesis of selected medicinally important compounds.

PHA G619 Screening Methods and Techniques In Pharmacology 3 2 5

Ethics in animal research, CPCSEA guidelines, Biochemical assays, qualitative and quantitative estimation of receptor specific drugs, animal handling, breeding, nutrition and diet manipulation for testing, methods and techniques involved, therein. Design and development of new animal models and evaluation techniques for co-morbid illnesses and their standardization, toxicological, teratogenic, carcinogenic studies, data analysis, normalization in tabular and graphical formats.

PHA G621 Advanced Medicinal Chemistry 32 5

Methods of Modern Drug Discovery such as Me too drugs, Peptidomimetics, Diversity oriented synthesis, Lead optimization, Rational Drug Design, etc, Pro-drugs, Combinatorial Chemistry, Principles of Green Chemistry in drug synthesis

PHA G622 Chemistry of Natural Drugs & Macromolecules 2 5

Size and shape of macromolecules, biomedical polymers, their structure, synthesis and function, chemistry of newer oral contraceptive agents, terpenes used as flavouring agents, newer phytochemical investigations in glycosides, alkaloids, etc.

PHA G623 Pharmaceutical Applications of Polymers 5 and Biopolymers

Analysis and design of materials used in contact with biological systems, surface molecular interactions, approaches to design materials that control cell functions and their application in tissue engineering, drug delivery, vaccines, and targeting. Basic concepts behind synthetic and bio-polymers that interfere with cellular biological functions, their manufacturing, characterization and applications of smart biomaterials in healthcare, nanotherapeutics. Wear particles, Cementless fixation, porous ingrowth materials, PSHA, chemically deposited coatings, Fracture fixation, fracture fixation plates, degradable fixation plate, bone screws and plugs, Calcium phosphate and polyalkenoate cements, Bone substitutes, autografts and allografts, Apatite glass ceramics, Bioglass/sol-gel, Porous ceramics, Porous metals and porous glass, Materials based on natural products, collagen based materials, alginates, hyaluronic acid and chitin, Blood contacting devices, vascular grafts, stents, catheters and heart valves, artificial organs.

PHA G624 Principles of Toxicology 5

Principles, Organization of Economic Cooperation and Development (OECD), International Council for Harmonization (ICH) guidelines, toxicity testing methods in organ systems – acute, sub-acute, chronic, dermal, inhalational, reproductive, genotoxicity, in vivo, in vitro, in silico toxicity studies, toxicokinetics evaluation in preclinical studies, saturation kinetics, mutagenicity, safety pharmacology.

PHA G625 Cellular and Molecular Pharmacology 5

Molecular basis of the action of drugs; characteristics of interactions between drug molecules and substrates of drug action in the cell including cell signalling pathways; molecular, biochemical and cell biological techniques; proteomics, epigenomics and pharmacogenomics in therapeutics, long non-coding RNA, pathophysiology of protease receptors.

PHA G626 Pharmacovigilance 4

Scope and purpose of pharmacovigilance, safety and Adverse Drug Reactions (ADRs)- causation, pre-clinical, human volunteer, post marketing surveillance studies, signal detection, assessment and risk/crisis management and planning, legislation, regulatory system, WHO, ICH, OECD, Council for International Organizations of Medical Sciences (CIOMS) guidelines, stakeholders perspectives, ethical principles transparency, pharmacovigilance of select organ systems such as cardiovascular, renal and conditions like pregnancy, pediatrics, geriatrics, current limitations and future perspectives, individualized therapy considerations.

PHA G627 Medical Devices and Testing 4

ISO and OECD guidelines for medical devices and related assay methods, in vitro and in vivo models for sensitization, toxicity and safety, Blood, system function analysis and their significance, drug eluting stents, pacemakers, prefilled, programmable drug delivery systems, dental and bone cements, replacement prosthetics for organs based on function, regulation, diagnostic instruments in healthcare, newer tools and techniques in diagnosis, treatment - such as Optical Coherence Tomography, fracture putty, tissue regeneration, robotic assist devices, etc.

PHA G632 Dosage Form Design 3 2 5

Role of physical, chemical and biopharmaceutical factors (preformulation studies) of drug in the design, manufacture and stability of dosage forms; dosage form factors affecting the absorption of drugs; Biopharmaceutical Classification System (BCS); development of in-vitro in-vivo correlation; Controlled release drug delivery systems; Design of delivery systems for various routes/purposes like oral (gastro-retention, colon targeted), parenteral, buccal/sublingual, nasal, ocular, pulmonary and transdermal.

PHA G642 Laboratory Project 6

Exercises illustrating principles discussed in theory courses.

PHA G645 Molecular Pharmacology 3 0 3

Molecular basis of the action of drugs; the characteristics of interactions between drug molecules and substrates of drug action in

the cell; molecular, biochemical and cell biological techniques; response of cells to pharmacologic agents.

Physics

PHY F110 Physics Laboratory 0 2 1

An introductory experimental course covering experiments in Mechanics, Oscillations and Waves. In addition to performing classic experiments in physics, the course aims at strengthening experimental skills and ability to take proper measurements. The course should motivate students to enter the exciting world of experimental physics.

PHY F111 Mechanics, Oscillations and Waves 3 0 3

Conservation Principles, Rotational Dynamics, Oscillations, Wave Motion, Reflection and Refraction, Interference, Diffraction, Polarisation.

PHY F112 General Physics 3 0 3

Philosophy of Science; Newton's laws of motion; Work Energy, Impulse and Momentum; Equilibrium; Moment of a force; Rotation; Periodic motion; First law of thermodynamics; Second law of thermodynamics; Electromagnetic waves; Interference and diffraction; Polarization; Relativistic mechanics; Photons, Electrons and Atoms; Quantum Mechanics; Atoms, Molecules and Solids; Nuclear Physics.

PHY F211 Classical Mechanics 3 1 4

Review of Newtonian mechanics, constraints and generalized coordinates, Lagrange's equation of motion, calculus of variation and principle of least action, central force motion, kinematics of rigid body motion, rigid body equations of motion, heavy symmetrical top, Hamilton's equations of motion, canonical transformations.

PHY F212 Electromagnetic Theory I 3 0 3

Review of mathematics - scalar and vector fields, calculus of scalar and vector fields in Cartesian and curvilinear coordinates, Dirac delta function; Electrostatics - electric field, divergence & curl of electric field, electric potential, work and energy in electrostatics, conductors, electric dipole; Electrostatics in Matter - polarization and field of a polarized object, electric displacement, linear dielectrics; Magnetostatics - Lorentz force law, Biot-Savart law, divergence & curl of magnetic field, magnetic vector potential, magnetic dipole; Magnetostatics in matter - magnetization and field of a magnetized object, the H-field, linear & non-linear magnetic media; Electrodynamics - electromotive force, electromagnetic induction, Maxwell's equations in free space, plane wave solutions of Maxwell's equations in free space.

PHY F213 Optics 3 0 3

Geometrical optics - light as rays, Fermat's principle, matrix methods in ray tracing; scalar wave theory of light, spatial and temporal coherence, theory of diffraction - Fresnel & Fraunhofer diffraction, diffraction at rectangular and circular aperture, diffraction around opaque objects; crystal optics - electromagnetic wave propagation in anisotropic media, birefringence, e-m waves in nonlinear media, elements of nonlinear optics; scattering of light - Thomson and Rayleigh scattering; elements of modern optics - lasers and applications, holography, fiber optics, Fourier optics.

PHY F214 Electricity, Magnetism, and Optics Lab 0 2 2

This lab will consist of experiments on electromagnetism, optics and lasers.

PHY F215 Introduction to Astronomy and Astrophysics 3 0 3

Introduction and scope, telescopes, distance and size measurements of astronomical objects, celestial mechanics, the Sun, planets, planet formation, interstellar medium, star formation, stellar structure, stellar evolution, star clusters - open clusters, globular clusters, the Milky-Way galaxy, nature of galaxies - normal and active galaxies, Newtonian cosmology, cosmic microwave background radiation, the early universe.

PHY F221 Modern Physics 3 0 3

Special theory of relativity; quantum mechanics and applications; atomic and molecular physics; statistical physics; nuclear physics.

PHY F241 Electromagnetic Theory II 3 1 4

Maxwell's equations in matter, boundary conditions on electric and magnetic fields; energy of e-m fields and Poynting's theorem, linear momentum and angular momentum of e-m fields, Maxwell's stress tensor; electromagnetic waves in dielectric media - reflection, refraction and transmission at interfaces; wave propagation in metals - absorption and dispersion; guided waves; potential formulation of e-m fields, retarded potentials & Jefimenko's equations, Lienard-Weichert potentials and fields of a moving point charge; dipole radiation & radiation due to point charges; special theory of relativity, relativistic mechanics, relativistic electrodynamics.

PHY F242 Quantum Mechanics I 3 0 3

Origin of the quantum theory - black body radiation, photoelectric effect, Compton scattering, electron diffraction, Bohr model of hydrogen atom, Frank-Hertz experiment, Bohr-Sommerfeld quantization condition; notion of wave function, statistical interpretation of the wave function, issues of normalization, the Heisenberg uncertainty relation; Schrodinger equation, stationary states and time independent Schrodinger equation, energy eigenvalues and eigenfunctions, one-dimensional problems - potential wells, potential barriers, the harmonic oscillator; Hilbert space formalism - state vectors, Dirac's bra-ket notation, observables as Hermitian operators, eigenvalues and eigenstates of Hermitian operators, the measurement postulate.

PHY F243 Mathematical Methods of Physics 3 0 3

Tensor analysis in Cartesian and curvilinear coordinates; linear vector spaces, linear transformations and theory of matrices; functions of a complex variable, contour integration and applications; elements of calculus of variation; series solution of ordinary differential equations, special functions, Sturm-Liouville theory; Fourier integral; partial differential equations of physics, solution of partial differential equations by separation of variables method, the Green function method.

PHY F244 Modern Physics Lab 0 2 2

This lab will consist of experiments on modern physics and electromagnetism.

PHY F266 Study Project 3

These courses include projects which are oriented towards readings from published literature or books about new frontiers of development or analysis of available database. These courses are normally available to students in second or higher levels. These courses must coterminate with project reports.

PHY F311 Quantum Mechanics II 3 0 3

Hilbert space formalism (continued from QM-I) - operators and their matrix representations, change of basis, position and momentum representations, commuting and non-commuting observables, the generalized uncertainty relation; the time evolution operator and Schrodinger equation, Schrodinger and Heisenberg picture, simple harmonic oscillator using operator method; angular momentum operators and their commutation relations, eigenvalues and eigenvectors of angular momentum, spherically symmetric potentials, the hydrogen atom; time independent perturbation theory, WKB approximation, variational method; time dependent perturbation theory, interaction of atom with classical radiation field; identical particles.

PHY F312 Statistical Mechanics 3 0 3

Review of Thermodynamics - First and the second law of thermodynamics, reversible and irreversible processes, entropy, absolute temperature, thermodynamic potentials; Statistical description of macroscopic systems - micro and macro states, phase space distribution, Liouville theorem, microcanonical ensemble, statistical definition of temperature, pressure and entropy; Canonical ensembles, probability distribution in canonical ensemble,

partition function and calculation of thermodynamic quantities, equipartition and virial theorems, Maxwell velocity distribution, paramagnetism, harmonic oscillators, polyatomic molecules; Grand canonical ensembles - probability distribution in grand canonical ensemble, grand partition function, calculation of thermodynamic quantities; Quantum statistics - indistinguishable particles, Bose-Einstein and Fermi-Dirac distribution, classical limit, photon statistics, Planck distribution; Ideal Fermi gas - equation of state of ideal Fermi gas, free electron gas in metals, Pauli paramagnetism, Landau diamagnetism, statistical equilibrium of white dwarf stars; Ideal Bose Gas - equation of state, Bose-Einstein condensation.

PHY F313 Computational Physics 3 0 3

Review of programming language - C/C++, Matlab and Mathematica; Functions and roots - Newton-Raphson method, rate of convergence, system of algebraic equations; Numerical integration - Romberg integration, Gaussian quadrature; Ordinary differential equations - Euler Method, Runge-Kutta method, predictor-corrector method, system of equations; Partial differential equations - boundary value problems, finite difference method, finite element method; discrete and fast Fourier transform; Eigen-value problems; Monte-Carlo method - random numbers, sampling rules, metropolis algorithm.

PHY F315 Theory of Relativity 3 0 3

Special theory of relativity : Experimental background and postulates of the special theory, Lorentz transformation equations and their implications, space-time diagrams, Four vectors, tensors in flat space-time, relativistic kinematics and dynamics, relativistic electromagnetism. General theory of relativity : Principle of equivalence, gravitational red shift, geometry of curved space-time, Einstein field equation, spherically symmetric solution of field equation.

PHY F316 Musical Acoustics 3 0 3

Mathematical description of sound waves; physical sound production by vibrations in different dimensions; perception of music by the human ear and brain, the scientific meaning of psycho-acoustic concepts of pitch, loudness and timbre; Fourier analysis as a tool for characterizing timbre; musical scales, harmonics and tones; musical instruments with plucked, bowed and struck strings, wood-wind instruments, reed instruments and the human voice, percussions instruments such as tympani, and drums; engineering for sound reproduction in transducers, mikes, amplifiers and loudspeakers; sound spectrum analysis; basics of signal processing for electronic music production, filtration and enhancement; rudiments of room and auditorium acoustics ; hands-on work and projects.

PHY F317 Introduction to Radio Astronomy 3 0 3

Overview of Astronomy, Stellar and Galactic Astrophysics, Bremsstrahlung, Synchrotron radiation, free-free radiation, and Compton scattering, Radiative- transitions/line-emission, The radio sky and sources of radio signals, Theory of statistical random signals, Radio telescopes and Radio observations. Techniques of Line and continuum observations, Pulsar observations. Radio telescopes, antennas and receivers. Single dish and interferometric observations, Beam patterns, aperture synthesis and deconvolution, Phased arrays, Flux and Phase Calibration techniques. Study some radio telescopes GMRT, VLA, OWFA.

PHY F318 Atoms and Photons 3 0 3

Quantum mechanical understanding of light in terms of photons, sources of light from atomic emissions, two-level systems, parametric down-conversion, one-photon and two-photon processes, quantum measurements, photon detection, counting and correlation measurements, photon statistics, single photon interference, phase and polarization, entanglement and EPR experiment, Bell's theorem, quantum cryptography and teleportation, atomic clock, quantum imaging.

Pre-requisite: PHY F242: Quantum Mechanics I OR PHY F345: Quantum Mechanics for Engineers OR CHEM F213: Physical Chemistry II

PHY F319 Spacecraft Systems 3 0 3

Space mission design: Elements of a space mission: the mission, the spacecraft, trajectories and orbits, launch vehicles, mission operations systems, mission management and operations systems engineering, Overview of orbit and constellation design, Designing for space: The physical environment of space and spacecraft system design, Mechanical design, Thermal design, Optical sensor technology, attitude determination and control systems (ADCS) sensor technology, Power systems, electromagnetic compatibility (EMC) and interfacing, Small satellite design: Micro/nano-satellite design principles, space mission design exercise.

PHY F320 Space Physics 3 0 3

Physics of Plasma, Sun and space environment, Terrestrial Upper Atmosphere and Sun –Earth Interactions, The Terrestrial Magnetosphere , Interaction of the Solar Wind with the Terrestrial Magnetic Field, Aurorae, Space Weather, Magnetic Activity and Substorms, Magnetic Storms, Geomagnetic Activity Indices, Importance and applications of Space Weather.

PHY F341 Solid State Physics 3 0 3

Crystal structure - direct and reciprocal lattice, Brillouin zone, X-ray diffraction and crystal structure; free electron theory of metals; periodic potential and band theory of solids, the tight-binding approximation; lattice vibration and thermal properties; semiconductors - energy band gap in semiconductors, carrier density of intrinsic and extrinsic semiconductors, the p-n junction; magnetism - paramagnetism and diamagnetism, spontaneous magnetism, magnetic ordering; super conductivity-basic properties, the London equation, elements of BCS theory.

PHY F342 Atomic and Molecular Physics 3 0 3

Interaction of electromagnetic field with atoms - transition rates, dipole approximation, Einstein coefficients, selection rules and spectrum of one electron atom, line intensities and shapes, line widths and lifetimes; one electron atoms - fine and hyperfine structure, interaction with external electric and magnetic fields; two electron atoms - para and ortho states, level scheme, ground and excited states of two electron atoms; many electron atoms - central field approximation, Thomas –Fermi model, Hartree- Fock method, L-S coupling and j-j coupling; Molecular structure - Born-Oppenheimer approximation, rotation and vibration of diatomic and polyatomic molecules, electronic structure and spin, rotational-vibrational and electronic spectra of diatomic molecules, nuclear spin.

PHY F343 Nuclear and Particle Physics 3 0 3

Bethe-Weizsacker mass formula, nuclear size, mirror nuclei, electric multipole moments, Spherically and axially symmetric charge distribution, electric quadrupole moment, nuclear magnetic moment, nuclear decay, alpha and beta decay processes, nuclear fission, Bohr-Wheeler theory, two-body problem, deuteron wave function with central and non-central potential, electric quadrupole moment & magnetic moment, exchange forces, low energy nucleon-nucleon scattering, scattering length, effective range theory, spin dependence of n-p scattering, magic numbers, independent particle model, collective model. Mesons and baryons, antiparticles, neutrinos, strange particles, eightfold way, quark model, intermediate vector bosons, four fundamental forces, basic vertices and characteristics of quantum electrodynamics, quantum flavordynamics and quantum chromodynamics, decays and conservation laws, basic ideas of standard model of particle physics, qualitative discussion of current issues in particle physics.

PHY F344 Advanced Physics Lab 0 3 3

This lab will consist of experiments on solid state physics, spectroscopy and nuclear physics.

PHY F345 Quantum Mechanics for Engineers 3 0 3

Wave particle duality, Schrödinger wave equation, probability and current densities, position and momentum operators and state space, expectation values of operators, normalization, particle in a box, particle in finite height barrier and finite well, reflection and

transmission, Harmonic oscillator, particle in linearly varying potential, Infinite potential well, delta function potential. Time dependent Schrödinger equation, time evolution of stationary states: Infinite well and harmonic oscillator, wave packets and time evolution with example, group velocity.

Crystals, one electron approximation, Bloch theorem, density of states in k space, effective mass theory, effective mass approximation in semiconductor heterostructures, density of states in energy, density of states in quantum well, K.P model for two-band semiconductor. Band structure calculations for cubic crystals, Nanostructures: quantum wire, quantum well, quantum dots

PHY F346 Laser Science and Technology 3 0 3

Introduction to lasers, theory of radiation, laser basics, optical resonators, longitudinal / transverse modes, pumping of laser media, Line broadening mechanism, Transient behaviour - Q-switching, mode locking, devices, techniques; Types of lasers - solid state lasers, gas lasers, liquid lasers, semiconductor laser, x-ray laser, free electron laser, maser; Non-linear optics: Phase matching, second harmonic generation, third harmonic generation, difference frequency generation, optical parametric generation; Applications of lasers : Industry, medicine, biology, optical /quantum communication, thermonuclear fusion, isotope separation, holography, laser cooling.

Pre-requisite: PHY F212: Electromagnetic Theory I or EEE F212 or INSTR F212 or ECE F212 : Electromagnetic Theory

PHY F366 Lab Project 3

PHY F367 Lab Project 3

These courses include projects involving laboratory investigation or laboratory development in the students discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

PHY F376 Design Project 3

PHY F377 Design Project 3

These courses are intended to impart training in design of product/ process or other artifact to the students in the discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.

PHY F378 Plasma Physics and its Applications 0 3

Introduction to plasma physics. Motion of single charged particles in Electric and Magnetic fields. Fluid description of plasma and study of waves in plasmas, Theory of instabilities in plasma, A Kinetic theory description of plasma and some basic plasma phenomenon, Applications of plasma physics to plasma based accelerators, plasma based energy radiation sources, magnetic confinement fusion, laser-plasma interaction, astrophysical plasma, and studying plasma physics using computer simulation.

PHY F379 Thin Film Technology 3 0 3

Overview of thin film technology, Structure and bonding of materials, Defects in thin film, Thermodynamics and phase diagram, Kinetics and diffusion mechanism, Surface nucleation and film growth, Epitaxy and growth modes, Basics of vacuum science and technology, Thin film growth technology, Epitaxial growth techniques, Structure and morphology of thin films, Surface reconstruction and surface chemistry, Electrical and magnetic properties, Special topics on thin film application, Laboratory based experiments or assignments related to thin films.

PHY F412 Introduction to Quantum Field Theory 3 1 4

Klein-Gordan equation, SU(2) and rotation group, SL(2,C) and Lorentz Group, antiparticles, construction of Dirac Spinors, algebra of gamma matrices, Maxwell and Proca equations, Maxwell's equations and differential geometry; Lagrangian Formulation of particle mechanics, real scalar field and Noether's theorem, real and complex scalar fields, Yang-Mills field, geometry of gauge fields, canonical quantization of Klein-Gordan, Dirac and Electromagnetic field, spontaneously broken gauge symmetries, Goldstone theorem, superconductivity.

PHY F413 Particle Physics 3 1 4

Klein-Gordan equation, time-dependent non-relativistic perturbation theory, spinless electron-muon scattering and electron-positron scattering, crossing symmetry, Dirac equation, standard examples of scattering, parity violation and V-A interaction, beta decay, muon decay, weak neutral currents, Cabibo angle, weak mixing angles, CP violation, Weak isospin and hypercharge, basic electroweak interaction, Lagrangian and single particle wave-equation, U(1) local gauge invariance and QED, non-abelian gauge invariance and QCD, spontaneous symmetry breaking, Higgs mechanism, spontaneous breaking of local SU(2) gauge symmetry.

PHY F414 Physics of Advanced Materials 3 1 4

Review of fundamentals of crystallography, structural properties of crystals, polymers and glasses, processes involved in materials preparation, viz., diffusion, phase diagrams, advanced techniques to prepare low dimensional systems and thin films, kinetics of phase transformations, Mechanical, structural, thermal and electrical characterization of advanced materials, e.g., high Tc superconductors, superionic conductors, conducting polymers, dielectrics, ferroelectric materials, polycrystalline semiconducting materials, magnetic semiconductors, magneto resistance and GMR materials, shape memory alloys.

PHY F415 General Theory of Relativity and Cosmology 3 1 4

Review of relativistic mechanics, gravity as geometry, descriptions of curved space-time, tensor analysis, geodesic equations, affine connections, parallel transport, Riemann and Ricci tensors, Einstein's equations, Schwarzschild solution, classic tests of general theory of relativity, mapping the universe, Friedmann-Robertson-Walker (FRW) cosmological model, Friedmann equation and the evolution of the universe, thermal history of the early universe, shortcomings of standard model of cosmology, theory of inflation, cosmic microwave background radiations (CMBR), baryogenesis, dark matter & dark energy.

PHY F416 Soft Condensed Matter Physics 3 1 4

Forces, energies, timescale and dimensionality in soft condensed matter, phase transition, mean field theory and its breakdown, simulation of Ising spin using Monte Carlo and molecular dynamics, colloidal dispersion, polymer physics, molecular order in soft condensed matter – i) liquid crystals ii) polymer, supramolecular self assembly.

PHY F417 Experimental Methods of Physics 3 1 4

Vacuum techniques, sample preparation techniques, X-ray diffraction, scanning probe microscopy, scanning electron microscopy, low temperature techniques, magnetic measurements, Mossbauer and positron annihilation spectroscopy, neutron diffraction, Rutherford backscattering, techniques in nuclear experimentation, high energy accelerators.

PHY F418 Lasers and Applications 3 1 4

Properties of laser light, theories of some simple optical processes, basic principles of lasers, solid-state lasers, gas lasers, semiconductor lasers, free electron lasers, liquid, dye and chemical lasers, dynamics of laser processes, advances in laser physics, Q-switching, modelocking (active and passive), saturable absorbers, Kerr lens mode locking, non-linear optics, laser spectroscopy, time resolved spectroscopy, multi-photon spectroscopy.

PHY F419 Advanced Solid State Physics 3 1 4

Schrodinger field theory (second quantized formalism), Bose and Fermi fields, equivalence with many body quantum mechanics, particles and holes, single particle Green functions and propagators, diagrammatic techniques, application to Fermi systems (electrons in a metal, electron – phonon interaction) and Bose systems (superconductivity, superfluidity).

PHY F420 Quantum Optics 3 1 4

Quantization of the electromagnetic field, single mode and multi-mode fields, vacuum fluctuations and zero-point energy, coherent states, atom - field interaction - semiclassical and quantum, the

Rabi model, Jaynes-Cummings model, beam splitters and interferometry, squeezed states, lasers.

PHY F421 Advanced Quantum Mechanics 3 1 4

Symmetries, conservation laws and degeneracies; Discrete symmetries - parity, lattice translations and time reversal; Identical particles, permutation symmetry, symmetrization postulate, two-electron system, the helium atom; Scattering theory - Lippman-Schwinger equation, Born approximation, optical theorem, eikonal approximation, method of partial waves; Quantum theory of radiation - quantization of electromagnetic field, interaction of electromagnetic radiation with atoms; relativistic quantum mechanics.

PHY F422 Group Theory and Applications 3 1 4

Basic concepts – group axioms and examples of groups, subgroups, cosets, invariant subgroups; group representation – unitary representation, irreducible representation, character table, Schur's lemmas; the point symmetry group and applications to molecular and crystal structure; Continuous groups – Lie groups, infinitesimal transformation, structure constants; Lie algebras, irreducible representations of Lie groups and Lie algebras; linear groups, rotation groups, groups of the standard model of particle physics.

PHY F423 Special Topics in Statistical Mechanics 3 1 4

The Ising Model – Definition, equivalence to other models, spontaneous magnetization, Bragg-William approximation, Bethe-Peierls Approximation, one dimensional Ising model, exact solution in one and two dimensions; Landau's mean field theory for phase transition – the order parameter, correlation function and fluctuation-dissipation theorem, critical exponents, calculation of critical exponents, scale invariance, field driven transitions, temperature driven condition, Landau-Ginzberg theory, two-point correlation function, Ginzberg criterion, Gaussian approximation; Scaling hypothesis – universality and universality classes, renormalization group; Elements of nonequilibrium statistical mechanics – Brownian motion, diffusion and Langevin equation, relation between dissipation and fluctuating force, Fokker-Planck equation.

PHY F424 Advanced Electrodynamics 3 1 4

Review of Maxwell's equations – Maxwell's equations, scalar and vector potentials, gauge transformations of the potentials, the electromagnetic wave equation, retarded and advanced Green's functions for the wave equation and their interpretation, transformation properties of electromagnetic fields; Radiating systems – multipole expansion of radiation fields, energy and angular momentum of multipole radiation, multipole radiation in atoms and nuclei, multipole radiation from a linear, centre-fed antenna; Scattering and diffraction – perturbation theory of scattering, scattering by gases and liquids, scattering of EM waves by a sphere, scalar and vector diffraction theory, diffraction by a circular aperture; Dynamics of relativistic particles and EM fields – Lagrangian of a relativistic charged particle in an EM field, motion in uniform, static electromagnetic fields, Lagrangian of the EM fields, solution of wave equation in covariant form, invariant Green's functions; Collisions, energy loss and scattering of a charged particle, Cherenkov radiation, the Bremsstrahlung; Radiation by moving charges – Lienard-Wiechert potentials and fields, Larmor's formula and its relativistic generalization; Radiation damping – radiative reaction force from conservation of energy, Abraham-Lorentz model.

PHYF425 Advanced Mathematical Methods of Physics 3 1 4

Course description is to be developed.

PHY F426 Physics of Semiconductor Devices 3 1 4

Course description is to be developed.

PHY F427 Atmospheric Physics 3 0 3

Course description is to be developed.

PHY F428 Quantum Information Theory 3 0 3

Classical Information, probability and information measures, methods of open quantum systems using density operator formalism, quantum operations, Kraus operators. Measurement and information, Entropy and information, data compression, channel

capacity, Resource theory of quantum correlations and coherence, and some current issues.

PHY F431 Geometrical Methods in Physics 3 0 3

Manifolds, tensors, differential forms and examples from Physics, Riemannian geometry, relevance of topology to Physics, integration on a manifold, Gauss theorem and Stokes' theorem using integrals of differential forms, fibre bundles and connections, applications of geometrical methods in Classical and Quantum Mechanics, Electrodynamics, Gravitation, and Quantum field theory.

PHY F432 Classical Theory of Fields: A Symmetry Perspective 4*

Rotations in real complex and Minkowski spaces laying group theoretical basis of 3-tensors and 4 tensors and spinors, transition from a discrete to continuous system, stress energy tensor, relativistic field theory, Noether's theorem, tensor and spinor fields as representation of Lorentz group, action for spin-0 and spin-1/2, and super-symmetric multiplet, introduction of spin-1, spin-2 and spin-3/2 through appropriate local symmetries of spin-0 and spin-1/2 actions.

PHY F433 Topics in Nonlinear Optics 3 0 3

Lorentz model for various order nonlinearities, properties of tensor elements; Second order processes (second harmonic generation, Pockels effect, optical parametric oscillator); phase matching in crystals; Third order processes (third harmonic generation, phase conjugation, Kerr effect, self-phase modulation, Raman effect, Stimulated Raman scattering (Stokes / anti-Stokes), Stimulated Brillouin scattering); Light interaction with plasma (waves in plasmas, Landau damping, absorption of light by inverse Bremsstrahlung, resonance absorption, two plasmon absorption, parametric decay, stimulated Raman scattering, stimulated Brillouin scattering); Concepts of ponderomotive force / energy, second harmonic generation in plasma, self-focussing, above threshold ionization, odd harmonic generation, optical field ionization, Coulomb explosion; Applications : Holography (low intensity), optical solitons (medium intensity), inertial confinement fusion (high intensity) and acceleration of charged particles with light (ultra-high intensity).

Pre-requisites: PHY F212 & PHY F213

PHY F434 Foundations of Quantum Mechanics 3 0 3

A review of pre-quantum (classical) theories from the lens of determinism, locality, ontology, measurement, and abstract spaces; A discussion on Bell's generic formulation of locality and ontological issues through gauge redundancy in the description of electrodynamics; Review basic quantum theory and develop a toolbox for simple quantum examples to be used later to address the issues of locality, ontology and measurement; The measurement problem; the locality problem; the ontology problem; Copenhagen interpretation; Bohm's Pilot wave theory; Bell's theorem; many world interpretations.

Pre-requisite: PHY F242: Quantum Mechanics I

PHY F435 Advanced Computational Physics 3 0 3

Molecular dynamics, Monte Carlo methods and its applications to various systems, cellular automata, complex systems, fractals, Discrete and fast Fourier transform, partial differential equations, FDTD, computational fluid dynamics.

Pre-requisite: PHY F313: Computational Physics

PHY F436 Space Science Instrumentation 3 1 4

Space environment: Vacuum (very low pressure), Thermal environment and thermal design, Solar spectrum and effects on measurements/instruments, Other sources of radiation, Galactic rays, Radiation environment and its effect on measurements/instruments, Plasma and charged particle environment, Meteoroid environment, Review of relevant physical processes: secondary electron emission (SEE), ion-surface interactions, photoemission, ionization, particle and photon scattering, Materials for space instruments: CTE, outgassing, mass loss, radiation damage, various properties and limitations, Detectors: Photon detectors, Particle detectors, Space Instruments: Dust detectors and analyzers, Magnetometers, UV spectrometers, IR instruments (thermal imaging, spectrometers), Imaging/cameras, Neutral/ion mass spec-

trometers, Plasma instruments (Faraday cups, solar wind analyzers, energetic particle detectors, Neutral particles (high and low energy

PHY F437 Scientific Computing and Data Analysis 3 1 4

Introduction to Scientific Computing: Review of programming language - C/C++, Matlab and Mathematica, The Role of Statistics in Machine Learning, Statistical Machine Learning Techniques, Advanced Statistical and Machine Learning: Foundations and Un-supervised Learning, Advanced Statistics and Machine Learning: Regression and Classification, Data Acquisition and Image Processing, Performance Modelling, Vectorisation and GPU Programming, Advanced Algorithms and Discrete Systems, Computational Linear Algebra and Continuous Systems

PHY F491 Special Project 3

This is an unstructured open-ended course where under the overall supervision of an instructor-in-charge, batches of students will be attached to different instructors. Each batch will work on a specific time-bound project which is of basic or peripheral concern of his discipline. Each student must submit a project report as a culmination of his endeavour and investigation. The instructor-in-charge will determine the choice of the project and also whether or not the project report is to be submitted jointly by a group or individually by a student. The course will aim to evaluate student's actual ability to use the fundamentals of knowledge and to meet new unknown situations as demonstrated by the students' interaction with the instructors and instructor-in-charge and aggregated in the project report. The instructor-in-charge may assign specific hours for formal brain-storming sessions.

PHY G511 Theoretical Physics 5

Calculus of Variations and its applications to Lagrangian and Hamiltonian Dynamics, Thermodynamics and Geometric Optics and Electrodynamics. Geometric and Group theoretic foundations of Hamiltonian Dynamics, Hamilton-Jacobi Theory, Integrability and Action-Angle Variables, Adiabatic Invariants, Transformation (Lie) Groups and Classical Mechanics. Modern Theory of Phase Transitions and Critical Phenomenon: Thermodynamics and Statistical Mechanics of Phase Transitions, General Properties (eg Scaling, Universality, Critical exponents) and Order of Phase Transitions; Introduction to Landau-Ginzburg (Mean Field Theory) theory for Second Order Phase Transitions, the Ising Model and some Examples, Phase Transitions as a *symmetry-breaking* phenomenon.

PHY G512 Advanced Quantum Field Theory 3 0 3

Diagrammatics : Feynman diagrams & rules, Loop diagrams, S-matrix, Path integrals, Gauge theories, QED and QCD Lagrangians, Renormalization group, Non-perturbative states.

PHY G513 Classical Electrodynamics 4

Review of Electrostatics, Magnetostatics, and solution of Boundary Value Problems. Method of Images. Maxwell equations for time dependent fields, Propagation of electromagnetic waves in unbounded media. Waveguides & Cavity Resonators. Absorption, Scattering and Diffraction, Special Relativity, Covariant formulation of Classical Electrodynamics. Dynamics of charged particles in electromagnetic fields. Radiation by moving charges and Cerenkov Radiation.

PHY G514 Quantum Theory and Applications 4

Mathematics of linear vector spaces, Postulates of Quantum Mechanics, Review of exactly solvable bound state problems, WKB methods, Angular momentum, Spin, Addition of angular momenta, Systems with many degrees of freedom, Perturbation theory, Scattering theory, Dirac equation.

PHY G515 Condensed Matter Physics 4

Free electron models, Reciprocal lattice, Electrons in weak periodic potential, Tight-binding method, Semiclassical model of electron dynamics, Theory of conduction in metals, Theory of harmonic crystals, Anharmonic effects, Semiconductors, Diamagnetism and paramagnetism, Superconductivity.

PHY G516 Statistical Physics & Applications 4

Liouville's theorem, Boltzmann transport equation, H-Theorem; Postulate of statistical Mechanics; Temperature; Entropy; Micro-canonical, Canonical, Grand-canonical ensembles - Derivation, calculation of macroscopic quantities, fluctuations, equivalence of ensembles, Applications, Ideal gases, Gibbs Paradox; Quantum mechanical ensemble theory; Bose-Einstein statistics –derivation, Bose Einstein condensation, applications; Fermi-Dirac Statistics – derivation, applications - Equation of state of ideal Fermi gas, Landau Diamagnetism, etc; Radiation; Maxwell-Boltzmann statistics; Interacting systems – cluster expansion, Ising model in 1-d & 2-d; Liquid Helium, phase transitions and renormalization group.

PHY G517 Topics in Mathematical Physics 4

Functions of complex variables, special functions, fourier analysis, Sturm-Liouville theory, partial differential equation with examples, Greens functions, Group theory, differential forms, approximation methods in solutions of PDE's, vector valued PDE's.

PHY G518 Computational Methods in Physics 3 2 5

Basics of computer programming; errors and stability of methods; Numerical techniques for: differentiation, integration, root finding, interpolation, solving linear equations, matrix inversion & diagonalization, solving ODEs & PDEs, spectral methods and Monte Carlo methods; Applications: 1D Schrodinger equation, Diffusion, Vibration of strings, Ising model, 3-body problem, Chaotic systems, Electronic structure of atoms. Power spectrum of a driven pendulum, Laplace equation, Wave equation, Scattering problems.

(This course is meant for PhD Students as a part of their course work)

PHY G521 Nuclear and Particle Physics 5

Course description for the above course is to be developed.

PHY G531 Selected Topics in Solid State Physics 5

Schrodinger Field Theory (2nd Quantized formalism), Bose and Fermi fields, equivalence with many body quantum mechanics, particles and holes, Single particle Green functions and propagators, Diagrammatic techniques, Application to Fermi systems electrons in a metal, electron-phonon interaction) and Bose systems (superconductivity, superfluidity).

PHY G541 Physics of Semiconductor Devices 5

Electrons and Phonons in Crystals; Carrier dynamics in semiconductors; Junctions in semiconductors (including metals and insulators); Heterostructures; Quantum wells and Low-dimensional systems; Tunnelling transport; Optoelectronics properties; Electric and magnetic fields; The 2d Electron gas; Semiconductor spintronic devices

M.E. Sanitation Science, Technology and Management

SAN G511 Sanitation Technology 3 2 5

This course aims to give the participants a review of the fundamentals as well as the latest technological developments applied in the field of sanitation. Urban Drainage and Sewerage, Carbon, nitrogen and phosphorus removal & recovery; sludge treatment, Site evaluation; toilets; onsite sanitation systems; emptying and transport; established and transferring technologies for dewatering, stabilization, pathogen inactivation and nutrient management, urban low cost drainage, Innovation processes, Intro & Exercise technology selection tool / decision support system; discussion comes.

SAN G512 Sanitation and Public Health 3 2 5

This course will have four modules – Introduction to Sanitation, Sanitation system and services, Public Health and Analysis of sanitation flow. Background on urban sanitation, Material flow analysis, Monitoring frameworks, Shit Flow Diagrams, Human Health Hazards and Waste, Review and Assessment of Transmission Routes, Review and Assessment of Transmission Routes, Disease Cycles – Lifecycles & Vectors, Control Measures, Risk Evaluation Tools, Urban development trends, demography, Urban sanitation planning & programming

SAN G513 Sanitation Governance, Behaviour Change and Advocacy 5*

This particular course will have two modules – Sanitation Governance and Behaviour change & Advocacy. Water & sanitation governance: definitions, debates, controversies, Power relations among actors in the local and global levels: Gender, class & race relations and power asymmetries, Practices of coordination & decision, making around contested water distribution, Case studies on regulatory frameworks around the world – how is sanitation managed: where, how and why, Everyday sanitation from different perspectives. Behaviour with reference to Societal and cultural aspects, Types: Knowledge, motivations and reactions, Reinforcements: Norms and behaviour Settings

SAN G514 Sanitation Financing and Project Management 5*

This course will have two modules – Sanitation Financing and Project Management. Introduction to financial viability, CAPEX, OPEX, business models and PPP of sanitation project, Calculating CAPEX and OPEX of a sanitation project and developing a business model, Local authority/municipal budgeting and public/government financing, Key aspects of project management including stakeholders' relationship, people management, risk management, budget management, reporting, Objective Oriented Project Planning.

SAN G515 Emergency Sanitation and Leadership 5*

This course will have two modules – Emergency Sanitation and Leadership. The evolution of humanitarian aid: historical events and the humanitarian system as it stands today. Overview of the international legal framework (Refugee law, International Humanitarian Law-IHL, International Disaster Relief Law-IDRL), code of conduct and guiding principles of humanitarian action. Standard supplied by relief agencies and global cluster, Sphere, WASH cluster. Disaster cycle, risk reduction/response/ recovery/ development, emergency response phases. Overview of relief organizations, their mandates, their commitments and priorities in emergencies.

Sanskrit

SANS F111 Sanskrit 3 0 3

Simple pieces of Sanskrit prose and poetry to be used for teaching the basic construction of Sanskrit words and sentences. The course will aim at making the student read elementary Sanskrit like a Subhashita Sloka or a Sloka from Ramayana or Mahabharata and be able to understand it with the help of a dictionary.

Russian

RUS N101T Beginning Russian 3 0 3

Basic grammar; vocabulary; reading practice; translation of simple passages.

Not available for meeting the requirements of any programme except as prerequisite for another Russian course. Can be taken only on audit

RUS N102T Technical Russian 3 0 3

Prerequisite: RUS N101T

Phrases and sentence patterns in technical literature; special technical vocabulary; reading and translation of current technical literature from Russian to English with the help of a dictionary. This course is designed to meet the foreign language requirement of the Ph.D. programme. Can be taken only on audit

Skill Area

SKILL G611 Computer Operation and Software Development I 5

SKILL G612 Computer Operation and Software Development II 5

These two courses to be offered in two successive semesters will aim to develop the computer skills for running program packages and writing and developing software programmes for as wide ar-

as possible. Areas would include both the developmental processes involved in innovative education and of academic and applied research.

The operation of and evaluation in the courses would be done through seminars, group discussions, log books and programme outputs. One component of the evaluation will invariably consist of a lengthy involvement on an intricate task.

SKILL G621 Computer Maintenance I 5

SKILL G622 Computer Maintenance II 5

These two courses, to be offered in two successive semesters, will aim to develop the skill for maintenance of computer systems. Through these courses the student would be required to acquire a competence of planned and preventive maintenance, trouble shooting safety procedures etc. If required the student may be asked to undergo part of his training in established computer maintenance organisations. The operation and the evaluation of this course would be achieved through practicals, log books, seminars, quizzes etc. One component of the evaluation will invariably consist of a lengthy involvement on an intricate task.

SKILL G631 Professional Communication I 5

SKILL G632 Professional Communication II 5

These two courses, to be offered in two successive semesters, will aim at imparting communicative competence and demand training in the art of teaching and development of subject matter pertaining to the overall goal of the programme. The courses will operate on unstructured basis and would be monitored by a team of teachers identified for the purpose. Professional Communication II will be a project Course and must coterminate with a project report.

SKILL G641 Modern Experimental Methods I 5

SKILL G642 Modern Experimental Methods II 5

These two courses to be offered in two successive semesters will impart experimental skills in modern areas of interest to the Institute. Emphasis will be laid on operation and use of sophisticated instruments. The organisation and evaluation of these courses would be achieved through practicals, demonstrations, discussion on significance of results, seminars, quizzes etc. One component of evaluation will invariably be full finding of lengthy assignments. These courses will be conducted by a team of teachers who will incorporate professional competence into experimental method taken up for study.

SKILL G651 Techniques in Development Management I 5

SKILL G652 Techniques in Development Management II 5

These two courses, to be offered in two successive semesters, will aim to lead a student into the theory and practice of activities connected with innovation, institutional change and development of teaching and research. Actual cases would be included from BITS. New cases are to be developed. The power of analysis design of models would be the main thread of treatment in these courses. These courses will be operated by a team of teachers. The organisation and evaluation would be achieved through practicals, log books, seminars, quizzes etc. One component shall invariably be a full finding of a lengthy assignment on a particular instrument (Technique) or their use in a larger context of teaching and research.

SKILL G661 Research Methodology I 5

SKILL G662 Research Methodology II 5

These two courses, to be offered in two consecutive semesters, are designed to impart training in methodology of research such as analysis of research problems, mathematical and statistical analysis of data, computer simulation methods, experimental techniques etc. The actual contents of these courses will depend upon the needs and research goals of a particular student. A project report has to be submitted by each student at the end of each course.

The organisation and evaluation of these courses would be achieved through seminars, group discussions, project reports etc. The courses will be conducted by a team of teachers.

Note: All the above mentioned Skill courses will be 'Unstructured' in the sense that they would be completely of 'non-lecture' type but would require committed involvement in the concerned professional engagement. Each course is a combination of two course numbers I & II running in two successive semesters where grades would be awarded for the two components separately. While normally a student will be required to take I & II, in rare occasions he may be asked to take only Course No. I depending on his prior preparation and the ultimate goal to be achieved through the programme. No student can register I and II of the same course concurrently in a semester. Where there is sufficient academic justification to meet the goals of these courses, the Dean Instruction may permit delayed registration in course No. II or in the pair of courses.

Software Systems

SS G511 Design and Analysis of Algorithms 5

Design techniques such as divide-and-conquer, recursion, backtracking, branch-and-bound, simulation; Analysis in terms of average level and worst level efficiency; Relationship to appropriate data structures; Illustrations dealing with problems in computer science, graph theory and mathematics; Computational complexity and bounds; NP-hard and NP-complete problems.

SS G512 Object Oriented Programming 4

Basics of object oriented programming: objects, classes, instances; inheritance; polymorphism; operator overloading; static and dynamic binding; small talk, C++, cases from other object oriented languages like Ada, Loop, Flavors, Objective-C, etc.; object oriented software engineering.

SS G513 Network Security 3 1 4

This course examines issues related to network and information security. Topics include security concepts, security attacks and risks, security architectures, security policy management, security mechanisms, cryptography algorithms, security standards, security system interoperation and case studies of the current major security systems.

SS G514 Object Oriented Analysis and Design 2 2 4

Object orientation concepts, theories and principles; fundamental concepts of the object model: classes, objects, methods and messages, encapsulation and inheritance, interface and implementation, reuse and extension of classes, inheritance and polymorphism; process of object-oriented requirements specification, analysis and design; notations for object-oriented analysis and design; case studies and applications using some object oriented programming languages.

SS G515 Data Warehousing 3 2 5

Introduction, evolution of data warehousing; decision support systems; goals, benefit, and challenges of data warehousing; architecture; data warehouse information flows; software and hardware requirements; approaches to data warehouse design; creating and maintaining a data warehouse; Online Analytical Processing (OLAP) and multi-dimensional data, multi-dimensional modeling; view materialization; data marts; data warehouse metadata; data mining.

SS G516 Computer Organization & Software Systems 5

Programmer model of CPU; Basic concept of buses and interrupts; Memory subsystem organization; I/O organization; Concept of assembler, linker & loader; Types of operating systems; Concept of process; OS functions: Process scheduling, Memory management, I/O management and related issues.

SS G517 Data Structures & Algorithm Analysis 5

Abstract data types; Linear data structures; Hash functions, Binary and other trees, traversal algorithms; Heaps and balanced

trees; Sorting and searching techniques; Divide and conquer, recursion, backtracking, branch and bound; Computational complexity and bounds.

SS G518 Database Design & Applications 5

DBMS architecture; Data models: Network model, Hierarchical model and Relational model; Database design & optimization; Query processing & Query optimization; Transaction Processing; Concurrency control; Recovery; Security & protection; Introduction to Object Oriented data model & Multimedia Databases.

SS G519 Social Media Analytics 3 1 4

Basics of social media, its modelling & representation, node classification, community detection, user behaviour, herd behaviour, influence, recommendations in SM, controversy detection, sarcasm detection, fake post detection, behavioural analysis, SM driven problems such as mental health, spreading rumours, etc.

Equivalent: CS G519

SS G520 Advanced Data Mining 3 1 4

Topics beyond conventional record data mining. Mining complex data structures. Tree/graph mining, sequence mining, web/text data mining, stream data mining, spatiotemporal data mining, mining multi-variate time series data, high-dimensional data clustering, and mining social networking sites. Mining data from multiple relations (Multi-relational Data Mining). Privacy preserving Data Mining. Distributed computing solutions for data intensive data mining.

SS G521 Fourth Generation Languages and Applications 4

Nature of 4GLs; application generators; RDBMS and 4GLs; SQL based 4GLs; 4GLs and development of information systems and decision support systems; other types of 4GLs; case studies.

SS G522 Software Development Standards 4

Standards and their role in software development; Institutions involved in formulating and promoting standards; operating environment standards; POSIX; software design standards; diagramming standards; coding standards; language design, code generation and usage standards; software portability and standards; standards in software development tools; standards in compilers and interpreters; open systems; OSI; user interface standards.

SS G523 Software for Embedded Systems 3 2 5

Real-time and embedded systems; software issues in embedded system; software development process; requirement analysis: use cases, identification and analysis of use cases, use case diagrams; design: architectural design, design patterns and detailed design; implementation: languages, compilers, runtime environments and operating systems for embedded software; testing: methodologies, test cases. The course will also consist of laboratory practices and development of software for embedded systems.

SS G527 Cloud Computing 5

Review of Distributed computing - Concurrency, message passing, connectivity and failure models, replication. Computing Infrastructure - Processing Power, Storage aggregation, I/O & Communication, Clusters and Data Centers. Resource modeling and virtualization - CPU virtualization, memory and storage virtualization, virtualized networks. Services - Service models and service contracts; Programming on the cloud. Cloud Applications - Software on the Cloud and Infrastructure Services. Cloud infrastructure - Private vs. Public Clouds, Resource scaling and Resource provisioning. Quality of Service - Performance models, scalability, Performance measurement and enhancement techniques. Security issues - Data/ Storage Security, Resource Access Control, Process Isolation and Control, Service Policies and Privacy Issues.

SS G531 Pervasive Computing 4*

Select application architectures; hardware aspects; human-machine interfacing; device technology: hardware, operating system issues; software aspects, java; device connectivity issues and protocols; security issues; device management issues and mechanisms; role of web; wap devices and architectures; voice-enabling techniques; PDAs and their operating systems; web application architectures; architectural issues and choices; smart card-based authentication mechanisms; applications; issues and mechanisms in WAP-enabling; access architectures; wearable computing architectures.

SS G532 Information Theory 4

Course description is same as given under BITS G532.

SS G541 User Interfaces 4**SS G542 Knowledge Management 3**

Increasing knowledge work in organizations; technologies to support growth of knowledge work in organizations; scope, cost, efficiency and reliability of technologies to support knowledge work; role of knowledge in an enterprise; knowledge management process; knowledge management strategies; human aspects of knowledge management; knowledge management technologies; applications of technologies to be covered through cases; reading assignments and use of appropriate software.

SS G551 Advanced Compilation Techniques 5

Generic Code Optimization Techniques - loop optimization, inlining, and other transformations. Impact of architectures on code generation and optimization: RISC architectures, VLIW architectures, special-purpose architectures. Architecture-specific code optimizations – register allocation, instruction scheduling. Code Optimizations under real-time / embedded constraints - cacheless / diskless memory models, bounded time responses. Garbage Collection Techniques. Virtual Machines and Just-in-Time Compilation techniques - HotSpot-like optimizations. Implementation of exception handling, concurrency, and generic jumps (like call/cc).

SS G552 Software Testing Methodologies 4

Concepts and principles of software testing and quality assurance; software testing tools, functional, structural, integration and system testing techniques; software testing process and its management; evaluation of test effectiveness; testing specialized systems and applications; automated software testing; case studies.

SS G554 Distributed Data Systems 3 2 5

Distributed File Systems - File System Models; Replication and Synchronization - Caching; Failure & Recovery; File System Security. Distributed Databases - Distributed Data Sources and Updates; Database Connectivity; Concurrency Control and Distribution mechanism; Distributed indexing schemes. Database security. Data on the Web - Web as a distributed data repository. Data Collection and Use Crawlers, Search Engines, and Indexing Schemes. Information Retrieval Techniques.

Data Exchange - Hierarchical Data Models, XML, and query languages. Semi-structured / Unstructured data - querying and synchronization.

Pervasive Data - Data distribution and access for non-computing devices, small computing devices, embedded computing devices and sensory devices.

SS G562 Software Engineering & Management 5

Current concepts, methods, techniques, and tools of the software engineering process; software process models; process definition and assessment; software measurement and metrics; project planning, estimation and control; requirements analysis and specification, design methods; quality assurance and testing; configuration management; process improvement; case

studies and project work.

SS G624 Computer Based Simulation and Modelling 5

Discrete event simulation on computers; Systems simulation & simulation languages; GASP & GPSS; Continuous simulation - languages and modelling techniques; Forrester's models; case studies.

SS G641 Management Information and Decision Support Systems 5

Data & information; characteristics of information; components of management information systems; information flows; design and maintenance of management information systems; decision support systems.

SS G651 Project Formulation and Preparation 5

This course is designed to inculcate principles of technical documentation as required within S&T organizations. Through this course, students are expected to acquire familiarity with several of the following: Proposals, feasibility reports, formal project reports, short reports, memos, negotiations, contracts, etc. In the process principles of project formulation and evaluation, such as technical considerations; performance specifications; preliminary block diagrams, types and analysis of contracts; cost estimation concepts, work breakdown structure; project data preparation, scheduling facilities etc., would be introduced. The course would invariably include the preparation of a detailed report embodying as many of the above concepts as appropriate.

SS G653 Software Architectures 3 2 5

Systems engineering and software architectures; Hatley-Pirbhai architectural template; architecture flow diagrams; requirements engineering and software architecture; architectural design processes; design post-processing; real-time architectures; architectural design patterns; software architecture and maintenance management; object oriented architectures; client-server architectures; forward engineering for object oriented and client-server architectures; emerging software architectures.