Sir Syed University of Engineering and Technology

Postgraduate Programmes

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MS Programmes

Overview

Duration

The duration for completing the MS degree requirements shall be minimum 02 years and maximum 04 years.

Admission Requirements

Education:

Sixteen years of schooling or 4-year education after HSSC or equivalent (minimum 124 credit hours), in relevant discipline from HEC recognized degree awarding institutes, with following minimum GPA or marks:

For Engineering Programs: 2.5 CGPA or 60% marks

For Non-Engineering Programs: 2.0 CGPA or 50% marks

(Additional deficiency courses may be assigned in case of non-directly relevant degree)

Test:

The SSUET MS Admission Test must be passed prior to admission in the MS Program. Valid result of NTS GAT General Test with a minimum 50% cumulative score can be accepted in lieu of admission test.

Interview:

Candidate has to appear in interview.

Studies

- Minimum 30 credit hours are required to be completed within allowed duration. These 30 credit hours will be in addition to any pre-requisite.
- A Student enrolled in a MS programme may take up to 09 credit hours of MS level courses from other disciplines subject to approval of individual courses as being acceptable by the department towards the student's MS degree.
- A student may undertake MS Thesis of 06 credit hours to be counted towards the 30 credit hours required for the MS degree.
- Minimum CGPA is required to be 2.5 out of 4.0 in the MS level courses.
- A student may repeat a MS level course in which grade point of less than 2.5 is achieved to improve the CGPA. The better grade will be used in the computation of CGPA.

Degree Requirements

Pass at least 10 MS level courses (meeting programme specific requirements) with minimum 2.5 CGPA.

OR

Pass at least 08 MS level courses (meeting programme specific requirements) with minimum 2.5 CGPA and pass MS Thesis.

MS in Biomedical Engineering

Core / Compulsory Courses

BM-6101 Modeling & Simulation of Physiological Systems
BM-6102 Research Methodology
BM-6103 Advanced Biomedical Signals & Systems
BM-6104 Biomedical Engineering Design
BM-6105 Biomaterial Science & Engineering

Elective Courses

BM-6201 Clinical Instrumentation
BM-6202 Embedded Systems & Applications
BM-6203 Medical Microsystems
BM-6204 Rehabilitation Engineering
BM-6301 Cell and Molecular Biology
BM-6302 Tissue & Cell Engineering
BM-6401 Medical Informatics
BM-6402 Telemedicine System
BM-6501 Pattern Recognition
BM-6502 Medical Image Processing
BM-7101 Biomaterials and Drug Delivery
BM-7201 Mathematical and Computer Modeling of Physiological System
BM-7301 Advanced Bio-Fluid Mechanics
BM-7302 Design of Medical Devices
BM-7321 Advanced Medical Imaging
BM-7499 Master Thesis

MS in Civil Engineering

The fields of specialization offered are:

- Structural Engineering
- Geotechnical Engineering
- Transportation Engineering and Management
- Construction Management
- Environmental Engineering

Structural Engineering:

Core / Compulsory Courses
CV-6101 Advanced Reinforced & Pre-stressed Concrete
CV-6104 Structural Dynamics
CV-6001 Advanced Engineering Mathematics
CV-7102 Mechanics of Solids
CV-7103 Advanced Structural Analysis

Elective Courses
CV-6106 Structural Mechanics
CV-6108 Earthquake Resistant Design
CV-6109 Sustainable Construction
CV-6111 Design of High Rise Structures
CV-6112 Bridge Engineering
CV-7105 Finite Element Methods
CV-7107 Advanced Steel Design
CV-7110 Plates and Shells
CV-7113 Advanced Concrete Technology
CV-7099 Thesis

Geotechnical Engineering:

Core / Compulsory Courses
CV-6201 Applied Soil Mechanics
CV-6203 Foundation Engineering & Design
CV-6205 Geology for Civil Engineers
CV-7202 Advanced Methods in Geotechnical Engineering
CV-7204 Advanced Analytical Geotechnical Engineering

Elective Courses
CV-6207 Soil Dynamics & Earthquake Engineering
CV-6208 Pavement Design
CV-6209 Geotechnical & Geo Environmental Engineering
CV-6210 Underground Excavating & Tunnelling
CV-6212 Pressure & Retaining Systems
CV-7206 Ground Improvement Techniques & Geo Synthetics
CV-7211 Rock Mechanics
CV-7099 Thesis

Transportation Engineering and Management:

Core / Compulsory Courses
CV-6301 Development of Transport Infrastructure
CV-6302 Urban Transportation Planning and Development
CV-6002 Probability and Statistics
CV-7303 Advanced Traffic Engineering and Management
CV-7304 Pavement Analysis and Design

Elective Courses
CV-6305 Geometric Design of Highways
CV-6307 Transport and Logistics Management
CV-6309 Highway Materials
CV-6310 Transport Economics
CV-6311 Public Transport Operations & Management
CV-7306 Sustainable Transportation Systems
CV-7308 Intelligent Transportation Systems
CV-7312 Supply Chain Management
CV-7099 Thesis

Construction Management:

Core / Compulsory Courses
CV-7401 Project Management
CV-7402 Total Quality Management
CV-7404 Construction and Industrial Law
CV-7403 Construction Operations and Productivity
CV-7405 Management of Design Process

Elective Courses
CV-7406 Statistics and Probability
CV-7407 Infrastructure Management in Public Sector
CV-7408 Human Resource Management in Construction Projects
CV-7409 Sustainability and the Built Environment
CV-7410 Information Technology Applications
CV-7099 Thesis

Environmental Engineering:

Core / Compulsory Courses
CV-6501 Environmental Engineering Design
CV-6502 Water and Wastewater Engineering
CV-6504 Solid Waste Management
CV-7503 Air Pollution & Control Engineering
CV-7505 Environmental Impact Assessment

Elective Courses
CV-6506 Environmental Management Techniques
CV-6509 Marine and Estuarine Environment
CV-6510 Environmental Measurements
CV-6511 Water Quality Management
CV-6512 Disaster Management and Risk Analyses
CV-7507 Environmental Auditing
CV-7508 Industrial and Hazardous waste management
CV-7099 Thesis

MS in Computer Engineering

The fields of specialization offered are:

- Computer Networks
- Software Engineering

Computer Networks:

Core / Compulsory Courses

CE-6103 Networking Protocols
CE-6104 Internetworking
CE-6126 Network Security
CE-7104 Research Methodology

Elective Courses

MS-6001 Mathematical Methods
CE-6109 Network Performance Evaluation
CE-6110 Networks and Optical Communication
CE-6111 Programming for Internetworking Applications
CE-6112 Stochastic Process Engineering
CE-6113 Digital Signal Processing (DSP)
CE-6114 Digital Communications
CE-6115 Wireless and Mobile Networking
CE-6116 Multimedia Networking
CE-6120 IT Project Management
CE-6125 Distributed Applications
CE-6127 Electronic Commerce
CE-6128 Network Management
CE-6211 Advanced Database Systems
CE-7190 Special Topics in Computer Networks-I
CE-7191 Special Topics in Computer Networks-II
CE-7105 Wavelet Analysis and Applications
CE-7106 Wireless Sensor Network
CE-7107 Cryptography
CE-7108 Digital Processing of Random Signals
CE-7109 Internet of Things
CE-7110 Cloud Computing
CE-7111 Software Defined Networking
CE-7205 Intelligent Systems
CE-6099 MS Thesis

Software Engineering:

Core / Compulsory Courses

CE-6241 Software Requirement Engineering
CE-6242 Software System Architecture
CE-6243 Software System Quality
CE-7104 Research Methodology

Elective Courses

MS-6001 Mathematical Methods
CE-6204 Software Quality Assurance

CE-6208 Information Systems Analysis and Design
CE-6209 Formal Methods in Software Engineering
CE-6210 Software Reliability and Safety
CE-6211 Advanced Database Systems
CE-6212 Database Security
CE-6214 User Interface Analysis and Design
CE-6215 Software Measurements and Metrics
CE-6233 Fuzzy Systems
CE-6251 Software Engineering Ontologies
CE-6252 Software Case tools and Applications
CE-7205 Intelligent Systems
CE-7206 Decision Support and Expert Systems
CE-7290 Special Topics in Software Engineering-I
CE-7291 Special Topic in Software Engineering-II
CE-7295 Case Studies and Projects
CE-6099 MS Thesis

MS in Electronic Engineering

The field of specialization offered is:

- Industrial Automation

Core / Compulsory Courses

EE-6107 Advance Power Electronics
EE-6102 Industrial Control Systems
EE-7101 Research Methodology
EE-7110 Stochastic Processes

Elective Courses

EE-6103 Advanced Digital Electronics and Interfacing Techniques
EE-6104 Electronic Design Automation
EE-6105 Measurement and Calibration of Electronic Systems
EE-6106 Intelligent Measurements and Instrumentation
EE-6108 Sensors and Systems
EE-6109 Robotics and its Application of Industrial Electronics
EE-6110 Selected Topics in Industrial Electronics
EE-6113 Fuzzy Logic and Intelligent Electronic Control Systems
EE-6114 Solid State Drives
EE-6115 FPGA Based Systems
EE-6199 MS Thesis
EE-7116 Digital Image Processing and its applications
EE-7102 Design of Industrial Control Systems
EE-7103 Mechatronics
EE-7104 Dynamics and Controls of Nonholonomic Systems
EE-7105 Embedded System Modeling
EE-7106 Advance Engineering Mathematics
EE-7107 Linear System Theory
EE-7108 Adaptive Systems
EE-7109 Advance Digital Signal Processing

MS in Mathematics

Core / Compulsory Courses

MS-6101 Real Analysis
MS-6105 Complex Analysis
MS-6201 Abstract Algebra
MS-6401 Ordinary Differential Equations

Elective Courses:

MS-6110 Measure Theory – I
MS-6115 Functional Analysis – I
MS-6120 Summability Theory – I
MS-6215 Ring Theory - I
MS-6501 Introduction to Continuum Mechanics
MS-6205 Linear Algebra
MS-6301 General Topology
MS-6601 Mathematical Statistics
MS-6901 Special Topics – I
MS-7110 Measure Theory - II
MS-7115 Functional Analysis - II
MS-7120 Summability Theory – II
MS-7125 Fourier Analysis
MS-7215 Ring Theory - II
MS-7220 Theory of Semigroups
MS-7225 Theory of Semirings
MS-7230 Fuzzy Set Theory
MS-7301 Algebraic Topology
MS-7401 Partial Differential Equations
MS-7405 Mathematical Techniques for Scientists and Engineers
MS-7410 Calculus of Variation and Integral Equations
MS-7415 Optimization
MS-7420 Integral Equations
MS-7425 Numerical Solutions of Ordinary Differential Equations
MS-7430 Numerical Solutions of Partial Differential Equations
MS-7435- Bio-Mathematics
MS-7501 Fluid Mechanics
MS-7510 Basics of the Theory of Fluids
MS-7515 Theory of Stability
MS-7520 Computational Fluid Dynamics
MS-7525 Aerodynamics
Ms-7530 Bio-Mechanics
MS-7601 Elementary Decision Theory
MS-7605 Operations Research
MS-7610 Approximation Theory
MS-7615 Stochastic Processes
MS-7620 Mathematical Modeling
MS-7701 Data Structure
MS-7705 Mathematical Coding Theory
MS-7710 Graph Theory
MS-7715 Theory of Computation
MS-7720 Numerical Analysis
MS-7801 Differential Geometry
MS-7901 Special Topics - II
MS-6099 Thesis

MS in Telecommunication Engineering

Core / Compulsory Courses

TE-6121 Communication Systems
TE-6122 Data Networks
TE-6123 Information Theory and Coding
TE-6124 Analysis of Stochastic Processes

Elective Courses

TE-6125 Digital Signal Processing
TE-6126 Wireless and Mobile Communication Systems
TE-6127 Management and Security of Telecommunication Networks
TE-6128 Broadband Communication Systems
TE-6129 Software Tools and Technique in Telecommunication
TE-6130 Antennas and Applied EM
TE-6131 Optical Communication systems
TE-6132 Digital Communication and Information Storage
TE-6133 Satellite Communication
TE 6134 Advanced Information Security
TE-7111 Lightwave Engineering
TE-7112 Advanced Communication Networks
TE-7113 Advanced Filter Design
TE-7114 IP Telephony
TE-7115 Teletraffic Engineering and Network Planning
TE-7190 Special Topics in Telecommunication-I
TE-7191 Special Topics in Telecommunication-II
TE-7199 Thesis

PhD Programmes

Overview

Duration

The duration for completing the PhD degree requirements shall be minimum 03 years and maximum 08 years.

Admission Requirements

Education:

HEC recognized Master's degree (MS, MPhil or equivalent) in relevant discipline with minimum CGPA of 3.0 out of 4.0 (in the semester system) or First Division (in the annual system).

Test:

SSUET/NTS GAT(Subjective) test must be passed with 60% marks, prior to the admission in the PhD Program in the area of specialization. SSUET GAT(Subjective) test for admission in PhD Programmes will be conducted as per NTS GAT (Subjective) format.

Interview:

An interview must be cleared that shall aim to assess the research potential of the applicant.

Coursework

- Course work of minimum 18 credit hours (06 PhD level courses) is required to be completed within 02 academic years. These 18 credit hours will be in addition to any prerequisite courses.
- A Student enrolled in a PhD programme may take up to 09 credit hours of PhD level courses from other disciplines subject to approval of individual courses as being acceptable by the department towards the student's PhD degree.
- Minimum CGPA is required to be 3.0 out of 4.0 in the 18 credit hours of PhD level courses that are to be counted towards PhD coursework.
- A student may repeat a PhD level course in which grade point of less than 3.0 is achieved to improve the CGPA. The better grade will be used in the computation of CGPA.

Comprehensive Examination

A Comprehensive Examination is required to be passed after completing PhD level courses with minimum CGPA of 3.0 and within 03 years of initial enrolment. The Comprehensive Examination is composed of a written part and an oral part.

PhD Candidacy and Research Work

- When a student qualifies both written and oral parts of the Comprehensive Examination, he/she shall be recommended for the confirmation of the PhD candidacy.
- After obtaining the PhD candidacy, the student is required to submit the written research proposal and present it in a seminar.
- During PhD candidacy, the scholar shall engage in creative and innovative research work (equivalent to 30 credit hours) leading to an original PhD thesis.
- Minimum duration of PhD candidacy is 02 years.

Degree Requirements

- Pass at least 06 PhD level courses (meeting programme-specific requirements) with minimum 3.0 CGPA in specified duration.
- Pass Comprehensive Examination Part A (Written) and Part B (Oral) in specified duration.
- Proposal Defense to be completed with BASR approval.
- At least 04 Progress Reports submitted and 02 Seminars delivered.
- Two peer-reviewed research papers accepted in HEC recognized journals or international conferences with at least one of these papers published in a journal recognized by HEC in category 'W'.
- Clear university plagiarism test of the PhD thesis as per HEC criteria.
- GEC approval of PhD thesis for external evaluation.
- Positive report on dissertation evaluation by two duly international experts.
- Open Defense of PhD thesis.
- Pass Thesis Examination conducted by the Defense Committee.
- Submit revised PhD thesis after Open Defense and Thesis Examination.

PhD in Biomedical Engineering

The offered tracks are as follows.
1. Bio Material and Regenerative Medicine.
2. Advanced Bio Instrumentation
3. Bio Imaging and Signal Processing

Core Courses (Select minimum 04 of the following)
BM-8101 Advanced Bio-Instrumentation Design
BM-8102Advanced Biomedical Signals Processing
BM-8103 Advanced Biomedical Imaging
BM-8104 Advanced Biomaterial
BM-8105 Bio nanotechnology
BM-8106 Advanced Modeling and Simulation of Physiological System

Elective Courses (Select maximum 2 from a track)
Biomaterial and Regenerative Medicine
BM-8201 Tissue Engineering
BM-8202 Material Engineering
BM-8203 Polymers in Drugs Delivery Systems
BM-8204 Regenerative Medicine
BM-8205 Bio Implants Material

Bio Imaging and Signal Processing
BM-8301 Radiological Imaging
BM-8302 Video Signal Processing
BM-8303 Advance Biomedical Optical Engineering and Design
BM-8304 MR Radiology and Spectroscopy

Advanced Bio Instrumentation
BM-8401 Neural Sciences and Neural Implants Devices
BM-8402 Sensors in Bio Instrumentation
BM-8403 Rehabilitation Engineering and Assistive Devices
BM-8404 Applied Bioelectricity
BM-8405 Innovating Medical Technologies

Thesis
BM-8099 PhD Thesis

PhD in Computer Engineering

Elective Courses

CE-7104 Research Methodology
CE-7105 Wavelet Analysis and Applications
CE-7106 Wireless Sensor Network
CE-7107 Cryptography
CE-7108 Digital Processing of Random Signals
CE-7109 Internet of Things
CE-7110 Cloud Computing
CE-7111 Software Defined Networking
CE-7206 Decision Support and Expert Systems
CE-7205 Intelligent Systems
CE-7295 Case Studies and Projects
CE-8001 Computer Vision
CE-8002 Optimization Techniques
CE-8003 Intelligent Data Analysis and Probabilistic Inference
CE-8004 Advanced Computer Systems Analysis
CE-8090 Advanced Topics in Computer Engineering-I
CE-8091 Advanced Topics in Computer Engineering -II

Thesis

CE-8099 PhD Thesis

PhD in Electronic Engineering

Core / Compulsory Courses

EE-7101 Research Methodology
EE-7102 Simulation, Modelling and Optimization
EE-8199 PhD Thesis

Elective Courses

EE-7116 Digital Image Processing and its applications
EE-7112 Design of Industrial Control Systems
EE-7103 Mechatronics
EE-7104 Dynamics and Controls of Nonholonomic Systems
EE-7105 Embedded System Modeling
EE-7106 Advance Engineering Mathematics
EE-7107 Linear System Theory
EE-7108 Adaptive Systems
EE-7109 Advance Digital Signal Processing
EE-8103 Computer Vision & Pattern Recognition
EE-8104 Advance Adaptive Control Systems
EE-8105 Non-Linear Control system
EE-8106 Advanced Topics in Electronic Engineering – I
EE-8107 Advanced Topics in Electronic Engineering – II

Course Descriptions

Biomedical Engineering Courses

BM-6101 Modeling & Simulation of Physiological Systems
Introduction: Model Human, an engineering point of View, mathematical Model, types and variation of models. Cell Physiology and transport: Gibbs-donnan Equilibrium, Carrier Mediated Transport action potential, Energetics of Muscle Contraction. Motion: Electrical analogy of steady Flow, Newton law of viscosity, Laminar flow and Viscosity of Blood, general form of equation of motion, sheer stress and endothelial cells. Signal Processing: Overview, signal acquisition and it's processing. Human Modeling: Techniques for Physiological system, Autoregressive modeling, time frequency analysis, physiology of autonomic nervous system and heart rate variability, Measurement of Physiological stress, cardiac rhythm, EMG and Its spectral analysis and mean power frequency, and EEG and Its spectral analysis & coherence. Modeling the respiratory System.

BM-6102 Research Methodology
Introduction: Problem identification, Problem Statement, Objectives, Literature Review & Referencing, Conceptual Framework/ Hypotheses, Planning, Methods and Procedures, Presenting Professional Papers. Data Collection & Analysis: Introduction to data col- lection and analysis, Statistical measures, hypothesis testing, linear regression and analysis of variance in application-oriented manner. Data collection methods using various instruments, Analysis of experimental and quasi-experimental methods. Presentation of re- search findings.

BM-6103 Advanced Biomedical Signals and Systems
Introduction: Origins of biomedical signals, challenges in acquisition and interpretation, time and frequency domain representation, Filter Design and applications, Random Signals: Random signals and stochastic processes, parametric and nonparametric estimation of power spectral density; case studies: Instrumentation: Signal acquisition, analysis and interpretation in a hospital, diagnostic laboratory. Time-frequency and time-scale analysis of biomedical signals, case studies. Adaptive processing of biomedical signals and applications. Emerging techniques in medical signal processing. Case studies: EEG/EMG and evoked potentials.

BM-6104 Biomedical Engineering Design
Introduction: Principles of Electronic Instrumentation, Biopotential measurements, Electrical and Electronic device design for Biomedical Engineering; laboratory experience designing devices for taking measurements of living systems. Analysis & Design: Principles, Skeletal and Cardiovascular Implant Design; Selection of material, Stress and Functional Analysis, Failure Criteria, Fatigue Analysis, and Optimal Design; case studies, Computer aided design methods, design of subsystems. Tools: Computational methods and tools in Design and Analysis, 3-D Modeling and Simulation, Systematic approach for Creation of Virtual 3-D models (digital prototypes), Visualization and Physical Simulation, Matrix transformations, Geometric modeling, Design of artificial organs and prostheses. Product Development: Product development for solving Biomedical, Biotechnological, and Ergonomic problems. Teamwork in design, Establishing Customer Needs, Writing Specifications, Legal and Financial Issues.

BM-6105 Biomaterial Science and Engineering

Basic understanding of materials' Properties, Biocompatibility, Performance requirements of materials for implants. Structure-property relationships, in vivo and vitro performances of polymers, metals, ceramics, glasses, etc,. used for manufacturing implants and de- vices. Practical experience in design, fabrication, and testing of bio- materials and devices; mechanical testing, tissue response, and de- sign to optimize response, interfacing for Biomedical Engineering, Principles of tissue engineering, cell-material interactions, cellular scaffolding and genetic engineering, in vitro and vivo models.

BM-6201 Clinical Instrumentation

Analysis and design of transducers and signal processors; measurements of physical, chemical, biological, and physiological variables; special purpose medical instruments, systems design, storage and display, grounding, noise, and electrical safety. Development of de- vices used in a clinical or biological environment.

BM-6202 Embedded Systems and Applications

Fundamentals of real time and embedded systems. Real time operating systems. Design methodologies. Development, debugging tools and programming languages. Reliability. Case studies and applications.

BM-6203 Medical Microsystems

Fundamental and advanced fabrication process for integrating materials into microstructures and micro devices. Micro patterning, moulding, sensing, and actuation technologies. Research concepts and applications of Microsystems at the molecular and cellular level. Applications such as DNA micro-arrays, drug and gene delivery, micro-sensors, actuators for research, microstructures for implants and micro-devices for prostheses.

BM-6204 Rehabilitation Engineering

Overview, Design and Prescription of prosthetic limbs, orthotic, seating & positioning systems. Introduction to injuries, disability, human movement, kinesiology. Biomechanics, Gait analysis, prosthetics, orthotics and mobility assist technology. Improvement of performance and prevention of injuries.

BM-6301 Cell and Molecular Biology

Structure-function relationships at the molecular and cellular levels. Emphasis on basic genetic mechanisms; control of gene expression; membrane structure, transport and traffic; cell signaling; cell adhesion; mechanics of cell division; and cytoskeleton.

BM-6302 Tissue and Cell Engineering

Tissue engineering approach for Augmentation or Replacement of Compromised Tissue, Function in Nerve, Micro-vessels, Skin and Cartilage. Integrative exploration, Use of Three-Dimensional Polymeric Scaffolds and Drug Delivery Vehicles. Gene Therapy and Cellular Engineering for Functional repair of Damaged Tissues.

BM-6401 Medical Informatics

History of Patient Record, Introduction to Computer Based Patient Record (CPR), Data from Patients, Coding and Classification, Strategies for Data Entry, Representation of Time and Clinical Use of the CPR, Clinical Departmental and Support Systems. Scope of Hospital

Information System (HIS), Challenges for the Health Care Sector, State of Transition, Objectives and Requirements, Planning, Modeling, Development, Architecture and Clinical Uses of HIS. Decision Support Models, Medical Reasoning, Quantitative & Qualitative Methods, Performance & steps involved, Uncertainty in Medical Judgment, Probability Theory and Decision Analysis. Characteristics & Implementing of Decision Support Systems.

BM-6402 Telemedicine System

Introduction & Benefits of telemedicine. Communication infrastructure – LAN and WAN technology. Satellite, Mobile, Internet technology for telemedicine. Video and audio conferencing. Medical information storage and management for telemedicine, patient information, medical history, test reports, medical images, diagnosis and treatment. Hospital information systems, Doctors, paramedics, facilities. Pharmaceutical, Security and confidentiality of medical records and access control. Cyber laws, Access to health Care Services, Health Education and Self Care. Bio-modeling, medical data coding and compression, Functions of DICOM, PACS and HIS for Telemedicine.

BM-6501 Pattern Recognition

Theoretical foundations of classification and pattern recognition. Applications in Object, Speech, Texture Recognition, Biomedical Pat- terns. Image sensing and measuring objects, features and patterns. Data acquisition, preprocessing, invariants, and representation is- sues. Feature Reduction, Classification. Classifier complexity, bias variance, local and global error, error estimations, rejects, ROC.

Bayesian approaches, Discriminant Functions for Normal Class Distributions, Parameter Estimation, Non-parametric Techniques (nearest neighbor rules, Parzen kernel rules, tree classifiers), Linear Discriminant Functions. Supervised learning (Perceptron, LMS algorithms, support vector machines, Back propagation), unsupervised learning and clustering, Neural networks, Combining Classifiers. Support Vector Machines, Hidden Markov Models. Applications of Pattern Recognition to Gene patterns and biomedical problems.

BM-6502 Medical Image Processing

Advanced image processing algorithms applied to analysis of medical images; image segmentation (level sets, watershed, active contours) and image registration (mutual information, Thirion Demons, B Spline algorithms); development and application of these algorithms using ITK Toolkit. Medical Image Enhancement, automatic Understanding & Diagnostic Systems.

BM-7101 Biomaterials and Drug Delivery

Principles of design and engineering of well-defined molecular structures and architectures intended for application in controlled re- leased and organ-tagged drug delivery. Therapeutic basics of Drug Delivery based on Drug Pharma dynamics and clinical pharmacokinetics. Biomaterials with specialized structural and interfacial properties to achieve drug targeting and perquisites.

BM-7202 Mathematical and Computer Modeling of Physiological Systems

Mathematical and computer modeling of physiological systems, Principal emphasis on cardiovascular system and individual nerve

cells; other topics include respiratory system and skeletal-muscle system; extensive use of “hands-on” computer.

BM-7301 Advanced Bio-Fluid Mechanics

Hemodynamic Theories of Atherogenesis, Womersley models, Steady and unsteady Flows in Curvature, Bifurcation and Branching Arterial Segments, Flow Dynamics, Past Prosthetic Implants. Experimental and Computational Models, Particulate and Mass Transport Simulations in Human Circulation.

BM-7302 Design of Medical Devices

Design of medical device, Problem identification, specifications, preliminary design, review, iteration, testing, marketing and economic considerations for manufacturing, Regulation, Controls and Clinical trials. Medical device system safety analysis and human factors. Medical product liability and malpractice.

BM-7321 Advanced Medical Imaging

Algorithms for Processing and Analyzing Large Volumetric Data-Sets; Process of CT, MRI, Ultrasound; SPECT, etc. 3-D convolution and filtering, geometric transformations, shape features, surface segmentation, regional segmentation, surface tiling, surface reconstruction, volumetric registration. 3-D Rendering, Image Integration & Tagging.

BM-7099 MS Thesis

Student has to take a topic for literature review and research under the supervision of his advisor. He/She has to submit the results of his findings in the form of a thesis/report and defend his findings in front of a panel of experts.

BM-8101 Advanced Bio- Instrumentation and Design

This course will introduce the advance level of biomedical instrumentation system, Building blocks of the biomedical Instrumentation systems, future need of biomedical instrumentations the course deal with advance bio instruments used to record the bio, detail discussion on origin of the bio signals, signal originated from the heart like sound signals from the movement of the heart valves, de- vices used to record the signal and its advancements, details analysis of electrocardiogram signal it instrumentation and advancements in the recording, Electromyogram system design, EMG signal interpretation and advancements in the current EMG devices its future Applications, electroencephalography signal interpretation , EEG sys- tem design advancement in the EEG device and its application in brain computer interfacing, Neural spikes amplifiers, electro muscles stimulator, the design and application and future advancements in the system, Future biomedical instrumentation trends, Advancements in the Xray, MRI and CT scan and PET Scan Systems. fMRI and its application in medical diagnosis, Advance instrument used for respiration System, implantable Biomedical Systems their application and limitations and future trends. Medical instruments and devices used in the home, future device for home and remote areas etc.

BM-8102 Advanced Biomedical Signals and Processing

This course will introduce the Nature of the biomedical signals, Noise removal and signal compensation of ECG and EMG signals, Biomedical examples of IIR digital filter design, Stochastic filter as filtered white noise, Random process, Digital Biomedical Signal Acquisition and processing, Time frequency signal representations of biomedical signals, Uncertainty management in medical applications, Nonlinear

behavior of heart rate variability, Ventriculo-Arterial interaction after acute increase of the aortic input impedance , Nonlinear Estimation of respiratory induced heart movement and its Application in ECG signal processing, Nonlinear deterministic behavior on blood pressure control, Wavelet Analysis in biomedical signal processing, Future Directions of biomedical signal processing and multimedia communication.

BM-8103 Advanced Biomedical Imaging Processing

This course will deals with the biomedical image processing, need of image processing in medicine, principles of image used in biomedical devices, types of imaging, components of image processing, image analysis, image managements, Magnetic resonance imaging, Spin echo, One dimensional Fourier imaging, k space and gradient echoes, slice excitation, sampling and aliasing in image reconstruction , projection reconstruction of images, MR angiography, motion artifacts and flow compensation, MR Spectroscopy, X-ray and computerized tomography, color X ray imaging, ultrasound imaging, tissue, Scattering, Ultrasound tissue phantom, Ultrasound beam formation, Ultrasound image modalities, Electrical impedance tomography, Optical Coherence Tomography, Medical application of virtual reality technology.

BM-8104 Advanced Biomaterial

This course will cover the introduction to the biomaterial, Application of biomaterial in Medical engineering, Need and requirement of Biomaterial in regenerative medicine and tissue engineering, Classes of materials used in medicine, Metals Polymers, FRPs, Glasses, Ceramics, bio-erodable material. Host reactions to biomaterials, Bio- compatibility, Implant associated infection, Testing of Biomaterials, In vitro assessment, in vivo assessments, Blood Materials interactions. Design on materials for biomedical application, Wound healing, Ophthalmologic applications, Sutures, dental implants, Cardio- vascular implants, neural implants, Skin and Orthopedic application. Implantation techniques for soft tissues and hard tissues replacements, Problems and possible solutions in implant fixation. Failure analysis of medical device and implants.

BM-8105 Bio Nanotechnology

This course will cover the introduction to the bio-nanotechnology, Application of bio-nanotechnology, Protein Engineering, tools for genome analysis, Microchip, Bioelectronics chips, Gene Chips. Micro fabrication processes of silicon and glass chips, Self-assembled monolayers Applications in surface modification and micro-patterning, Fabrication of polymer Microfluidic devices, Noncontact microar raying techniques, electronic manipulation of cells on a microchip based devices, micro-filters based separation of cells, Technology options and applications in microchips, Micro-fabricated devices for integrated DNA Analysis, Biochip based portable laboratory, biologi cal applications of paramagnetic particles in chips, and Nano scale size based bio-molecular separations technology.

BM-8106 Advanced Modeling and Simulation of Physiological System

This course deals with the definition of Modeling and simulation, in importance, Types of modeling and its Application in biomedical en

gineering with examples. Hybrid models and its application in bio-medical engineering, example of simulators. Multi-scale modeling its application in biomedical engineering and its examples. Conceptual Modeling, why and when to use the conceptual model. Things necessary before building a model. Conceptual model of cardiorespiratory system Subdivision of Physiology models and combining of basic elements of Conceptual models. Mathematical Models. Mathematical model of Mechanical and electrical system. Mathematical model of electrical system. State space variable and derivation of its equations. Example of State space equation and transfer its relation with transfer function. Representation of fluid and biomedical system in electrical component diagram. Electrical and mechanical modeling of the blood flow through the artery. Introduction to the software implementation of model. Flow diagram of the software implementation. Electrical model of the Skin. Use of Skin model in Electrical Impedance Plethysmography. Electrical model of the electrode. Ap- plication of electrode electrolyte model by attaching the electrode. Bio Heat equation and its derivative. Application of bio-heat equa- tion in simulation and modeling. Model of the brain and temperature effect on implanted Deep Brain stimulation electrodes. Modeling of the Human Eye. Electrical Modeling of the Neuron and Cable Theory. Block diagram of Middle Ear and its Electrical Modeling. Electrical Model of the Respiratory System. Three Block Model of the Renal System. Monti-Carlo Simulation of the Photon Movement in the Biological Tissue. Model design in COMSOL Multiphysics Software, de- signing of the electrode and identify the electrical field passing through the medium using COMSOL.

BM-8201 Tissue Engineering

This course will cover biological principles and physiological phenomena underlying cellular regulation during development, homeostasis, and cell proliferations and wound healing. The course also includes tissue engineering fundamentals, such as cell sources, trans- plantation immunology, processing of scaffolding materials, integration at cell-material interfaces, mechanisms of incorporation and re- lease of biologics, engineered culture environments, and host-trans- plant integration. A Brief Introduction to Different Cell Types, Human Embryonic Stem Cells, Derivation and Culture of embryonic stem cell, Stem Cells Differentiation, Marrow Stem Cells, Cord Blood Stem Cells Potentials and Realities, Control of Adult Stem Cell Function in Bioengineered Artificial cell and functions, Stem Cell and tissue Immunology, Development of a Design of Experiment Methodology, Applications to the Design and Analysis of Experiments, Synthetic Biomaterials as Cell-Responsive Artificial Extracellular Matrices, Bioactive Composite Materials for Bone Tissue Engineering Scaffolds Aggregation of Cells Using Biomaterials, Nanotechnology for Tissue Engineering, Microscale Technologies for Tissue Engineering, Cell Expansion, Cell Encapsulation, 3D Cultures, Stem Cell Therapy (Past, Present, and Future, Tissue Engineered organs and implants, Tissue Engineering for Tooth and Bone Regeneration, Animal Model and material compatibility, In Vitro 3D Human Tissue Models for Osteochondral Diseases, Application of Tissue Engineering according to the latest trends and Technology, importance of clinical trials and its outcomes.

BM-8202 Bio-Material Engineering

The course deals with the material the biological materials used in the field of biomedical. The fundamental of the course is the material and its types, bio material and artificial materials used as bio implants. The advance physical and chemical properties of the materials. design of the biomaterial, physical, chemical and behavior of the material in and outside the biological system. Synthetic Biomaterials as Cell-Responsive Artificial Extracellular Matrices, Bioactive Compo- site Materials for Bone Tissue Engineering Scaffolds Aggregation of Cells Using Biomaterials. The development of new scaffolds for re- generative medicine, biomaterials characterization, stem cell therapy, cell-materials interface engineering, self-assembled bio-mimetic copolymers and nanomaterials for bio sensing applications. Biomaterials activities are particularly exciting is the tailoring of in- organic nan-particles such as gold and quantum dots with bioactive peptides so that they can act as reporters for the detection of enzyme activity. Ultrasensitive detection of enzymes related diseases such as cancer or infectious diseases. Natural and synthetic materials as well as the interactions between materials and biological tissues. It covers a wide range of research areas including advance materials science, biocompatibility, implant device development, surgical applications, and failure analysis and has application throughout most physiologic systems. Application of material Engineering according to the latest trends and Technology, importance of clinical trials and its outcomes.

BM-8203 Polymers in Drugs Delivery Systems

It will focus on topics at the interface between engineering and medicine such as polymer chemistry, biomaterials, mass transport, and pharmacokinetics. The course will first cover the fundamentals of drug delivery, including physiology, pharmacokinetics/pharmacodnamics, drug diffusion and permeation, and biomaterials used in drug delivery course, Fundamentals and challenges of drug delivery, Barriers to Drug Delivery, In vitro models in drug discovery and de- livery, Routes of Drug Delivery, Pharmacokinetics, Pharmacodynamics, Diffusion in Biological Systems, Drug Metabolism, Polymer Selec tion, Polymer Characterization, Hydrogel drug delivery systems, Pol- ymer Microparticles/Nanoparticles/ Micelles/Vesicles, Polymer- Drug Conjugates, Implantable Drug Delivery Systems, Drug Delivery in Tissue Engineering, Controlled Release Drug Delivery, Mucoadhesive Drug Delivery Systems, Stimuli-Responsive Polymer Delivery Systems, Affinity Based Drug Delivery, Drug Targeting, Pro-drugs/ Bio-conjugation.

BM-8204 Regenerative Medicine

Regenerative medicine course includes the following are topics Bio-materials: including novel biomaterials that are designed to direct the organization, growth, and differentiation of cells in the process of forming functional tissue providing both physical and chemical cues.

Cells: including enabling methodologies for the proliferation and differentiation of cells, acquiring the appropriate source of cells such as autologous cells, allogeneic cells, xenogeneic cells, stem cells, genetically engineered cells, and immunological manipulation. Biomolecules: including growth and other differentiating factors. Engineering design aspects: including 2D cell expansion, 3D tissue growth, bioreactors, vascularization, cell and tissue storage and shipping (biological packaging).

Biomechanical aspects of design: including properties of native tissues, identification of minimum properties required for engineered tissues, mechanical signals regulating engineered tissues, and efficacy and safety of engineered tissues. In this course, we will intro- duce most of these elements through some examples that have al- ready successfully reached the clinics and others that have still to be further improved to enter daily clinical practices.

BM-8205 Bio Implantable Material

The course will include (i) biomaterials used for the implants, (ii) surface modification and coatings (iii) biomechanics aspects of the implant (iv) corrosion and tribocorrosion aspects of the implants (v) Clinical concerns. Some other topics related with implants such has Introduction of Biomedical implants, Different types of implants used in dentistry, orthopedics, and Cardiac implants, Implant materials, Implant design, Surface coatings and modifications, Mechanics of implant in action- Contact stresses and forces, Corrosion aspects, Tri-bocorrosion aspects, Major failure mechanisms, Lab experience from dental and hip implant simulator, Diagnostic techniques for the implant monitoring in orthopedics and dentistry, Material selection and economic impact, Clinical issues and concerns, Current status and future direction.

BM-8301 Radiological Imaging

The course will cover the advance techniques used for the radiological imaging and its types. The importance of the radiological imaging for diagnoses, treatment, and therapy of the disease. Advance physics applied for the generation, transmission and acquisition of the radiological signals. Signal and body interface, effect on the biological tissue before, during for the Source of the Radiological images. Radiation biology and protection. Radiological Pathology, digital vascular imaging, computed tomography (CT), general ultrasound and magnetic resonance imaging (MRI). Head and soft tissue imaging, cardio vascular and pulmonary imaging, spinal stenosis imaging, stroke imaging. Techniques, trends and technology of the imaging. Extraction of the information from the radiological images. Format and manipulation of the images. Diagnostic techniques for the radiological imaging in orthopedics and dentistry, cardio vascular and pulmonary system. safety procedure and precautions. economic impact, Clinical issues and concerns, Current status and future

BM- 8302 Video Signal Processing

The course will cover the advance techniques used for the video signal techniques. The course includes the elaboration of the Video Analysis and Video Processing. Video Analysis and Video Processing, Video Coding and Transmission, Compensated Multi-Dimensional Wavelet-Lifting, Compressed Domain Video Analysis, Image Reconstruction from Arbitrary Pixel Meshes, Objective quality evaluation of video, Reconstruction of HDR Videos using Multiple Camera Set- ups, Reconstruction of Non-Regularly Sampled Data, Resolution Enhancement Techniques for Compressed Video Sequences, Signal processing for digital camera systems, Video processing for multi camera systems. Coding and Processing of Non-Rectilinear Image and Video Data, Coding medical datasets, Compression of Display data, Energy Efficient Video Coding, Error Concealment of Image Data, High Quality Video Coding, Spatio-Temporal Prediction. Theory of Multidimensional Signals and Systems, implementation of the Signal transmission and its

techniques. The display and reading of the video signals and its format. The use of Video signals in medical and medical devices. The comparison of the conventional and the latest used videos signal devices. The advancement in the trends and technology and its barriers.

BM- 8303 Advanced Biomedical Optical Engineering and Design

The course will cover the advance techniques used for the optical Engineering in the field of Biomedical. The course includes the detail knowledge of the Light Propagation in Microstructure Optical Fibers and Designing High Gain Fiber Amplifier. Details and application of the Fiber Optics and Devices. Nano-photonics, Bio-photonics and Bio-medical Optics, Diagnosing Heterogeneous Dynamics for CT Scan Images of Human Brain in Wavelet and MFDFA Domain. Automated Detection of Optic Disc in Fundus Images. Three-Dimensional Optical-Resolution Photoacoustic Microscopy. Fluorescence Microscopy Imaging in Biomedical Sciences. Spectral Imaging: Methods, Design,

and Applications. Optical Coherence Tomography: Technical Aspects. Introduction to Biomedical Optical Imaging. Optical Fibers in Biomedical Imaging. Microscope Optics. Fluorescence Imaging and Techniques. Polarization Imaging. Confocal Imaging. Endoscope Optics.

BM- 8304 MR Radiology and Spectroscopy

The course will cover the fundamentals of the Magnet resonance phenomena. The Advance technique for the MR Radiology and Spectroscopy. The application of the MR in the Radiology. MR imaging and acquiring of the Image data. Methods and formulation of the Technique for the data analysis. Signal, noise and data analysis and its difference. Advance filters and algorithm for the data process. Latest trends and technology in MR radiology and spectroscopy. Introduction to the Spectroscopy in Vivo. Pulse sequence and protocol design. Normal regional variation, MR in neurology. MR in Cardiology, MR in traumatic injury. MR in cancer diagnoses and its importance.

BM- 8401 Neural Sciences and Neural Implants Devices

The course will include the Microelectronic Visual Prostheses, Visual Prosthesis for Optic Nerve Stimulation, Cochlear Implants, Auditory Prosthesis Using Deep Brain Stimulation: Development and Implementation, Spinal Cord Stimulation: Engineering Approaches to Clinical and Physiological Challenges, Microelectrode Technologies for

Deep Brain Stimulation, Implantable Cardiac Electro-stimulation Devices, The Bion1 Microstimulator and its Clinical Applications, Brain Control and Sensing of Artificial Limbs, Magnetic Stimulation of Neural Tissue: Techniques and System Design, and Regulatory Approval of Implantable Medical Devices in the United States and Europe,

BM- 8402 Sensors in Bio Instrumentation

The course will include the Introduction to the bio sensors, Temperature Sensors, Humidity sensors, Tilt Sensors, Pulse sensors, Accelerometers and it application in biomedical Instrumentation, Pres- sure Sensor and its application in Biomedical instrumentation, capacitive sensors and its application in biomedical instrumentation, Optical sensors in medical care, Bio sensors for monitoring glucose, Non- Invasive cardiovascular hemodynamic measurements, Sensors for Respirator system, Sensors for fetal and neonatal monitoring, Body Motion Analysis, Cardiac Pacemakers, Sensors for Catheter Applications, Home Health Care and Telecare. Normal regional variation, MR in neurology. MR in Cardiology, MR in traumatic

injury. MR in cancer diagnoses and its importance.

BM- 8403 Rehabilitation Engineering and Assistive Devices

The course will include the Principles of Assistive Technology: Intro-

Technologies That Aid Transportation, Technologies That Aid Manipulation and Control of the Environment, Sensory Aids for Persons with Visual Impairments, Sensory Aids for Persons with Auditory Impairment, Assistive Technologies for Cognitive Augmentation, and Augmentative and Alternative Communication Systems, Inducing the Human Activity Assistive Technology Model, Technologies that Assist People Who Have Disabilities, Activity, Human, and Con- text: The Human Doing an Activity in Context, Ethical Issues in Assistive Technology, Control Interfaces for Assistive Technologies, Accessing Mainstream Information and Communication Technologies: The Technology and the Web, Technologies that Enable Mobility,

BM-8404 Applied Bioelectricity

The course will include the Impedance and Current Distribution, Electrical Principles of Nerve and Muscle Function, Excitation Mod- els, Electrical Properties of the Heart, Cardiac Sensitivity to Electrical Stimulation, Sensory Responses to Electrical Stimulation, Skeletal Muscle Response to Electrical Stimulation, Stimulation via Electric and Magnetic Fields, TENS for pain management, TENS equipment, techniques, and biophysical principles, Appropriate electrode sites and electrical characteristics for TENS, Mechanism of action of TENS, and The use of TENS for non-painful conditions, Functional electrical Stimulation, Biosignal control based electrical stimulation.

BM- 8405 Innovating Medical Technologies

The course will include the all the expects of device design which in- cludes Identification: Strategic focus, needs exploration, Need state- ment development Screening: Disease state fundamentals, Existing solutions, Stakeholder analysis, Market analysis, Needs selection Concept Generation: Ideation, Initial concept selection Concept Screening: Intellectual property basics, Regulatory basics, Reimbursement basics, Business models, Concept exploration and testing, Final concept selection

Strategy Development: IP strategy, R&D strategy, Clinical strategy, Regulatory strategy, Quality management, Reimbursement strategy, Marketing and stakeholder strategy, Sales and distribution strategy, Competitive advantage and business strategy Business Planning: Operating plan and financial model, Strategy integration and communication, Funding approaches, Alternate pathways.

BM-8099 PhD Thesis

Student has to take a topic for literature review and research under the supervision of his advisor. He/She has to submit the results of his findings in the form of a thesis/report and defend his findings in front of a panel of experts.

Civil Engineering Courses

CV-6101 Advanced Reinforced and Pre-stressed Concrete
Introduction, Behaviour and design of beams-Review, Behaviour and design of Short Columns- Review, Behaviour and design for Slender Columns, Two Way Slab Systems, Strip Method, Direct design method, Equivalent frame method, Shear in walls, Structural Walls, Prestressed Concrete- elastic analysis, prestress losses, deflections, flexural and shear strength, bond and anchorage.

CV-6104 Structural Dynamics
Single degree of freedom systems: Formulation of the equation of motion and its methods of formulation, Free vibration response; un damped free vibration and damped free vibration; Response to different types of dynamic loadings and different methods of analysis of nonlinear structural response. Development of software in C++ language.

CV-6001 Advanced Engineering Mathematics
Numerical solutions of linear algebraic equations; Solutions of non-linear using first and second order iterative methods; Numerical differentiation and integration; Partial differential equations and finite difference methods; Eigen value problems such as plates. Laplace equations; Applications of Legendre, Chebyshev, Hankal and Bessel Functions to Structural Problems. Application of Taylor Series, Runge Kutta Method. Calculus of Variation, Euler Lagrange equations, Raleigh-Ritz & Galerkin techniques. Development of software for all numerical techniques in C++ language.

CV-6106 Structural Mechanics
Introduction, Energy Principles- principle of virtual work, potential energy, complementary energy, Stability Theory- Euler method, non-conservative systems, Review of Classical Beam Theories- Euler-Bernoulli and Timoshenko, beam theories, energy methods, large de- flections (beam-columns), stability (planer and lateral buckling), Classical Plate Theories- Kirchhoff and Reissner Mindlin plate theories, solution methods, energy methods.

CV-6108 Earth Quake Resistant Design
Introduction- Basis of earthquake philosophies, role of uncertainty and the management of risk, an 'ideal' approach and some practical simplifications, limit state approaches, approaches adopted in cur-rent and emerging building code provisions, Sources of Earthquake ground motions, measures of earthquake intensity and damage potential, effects of local soil conditions on ground shaking, engineering estimation of ground motion characteristics based on deterministic and probabilistic approaches, Assessment of the effect of structural system and ground motions on the response of simple one and multiple degrees of freedom systems, Development of Design Earth- quakes for Linear and Non-Linear Structural Response, Analytical Procedures for Preliminary/ Conceptual Design and Proportioning of Structural Systems, Code Related Issues, Applications.

CV-6109 Sustainable Construction
Patterns of Development-current global patterns, sustainable development, Global Environment Issues, Life Cycle Assessment

(LCA),

Sustainable Design-Introduction, principles and strategies, Design for Environment, Sustainable Consumption.

CV-6111 Design of High Rise Structures

Design Criteria- design philosophy, architectural requirements, loading, strength and stability, stiffness and drift limitations, human comfort criteria, creep, shrinkage and temperature effects, Gravity Load Resisting Systems-composite steel floor systems, precast concrete floor systems, post-tensioned concrete floor systems, Lateral Load Resisting Systems- moment resisting frames, brace frames, shear wall systems, core and outrigger systems, tubular systems, hybrid systems, Modelling for Analysis-Assumptions, computer modelling for accurate analysis, dynamic analysis, Fire Safety Engineering- fire protection systems, fire-resistance-rated construction , Foundation Systems and Construction Techniques-foundation systems, shallow foundations, pile foundations, raft foundation design and analysis, settlement aspect of foundation for tall buildings, basement excavation design and construction, Project Management for Tall Buildings- planning and scheduling, design management and constructability reviews, value engineering, site control.

CV-6112 Bridge Engineering

Introduction to bridge engineering, Historical perspective, Structural members- Materials, structural types, Selection of site, Bridge loads - dead load, live load, Live load moments and shears, influence lines, dynamic load (impact), Longitudinal loads. Load combinations, Bridge substructure - pier, abutment, pile, Design of concrete slab, Design of non-composite steel girders, Design of non-composite steel girders, Design of composite steel girders, Design of composite steel girders, Design of prestressed concrete girders, Composite actionshear connectors, Bridge tests and NDT procedures, Evaluation of existing bridges, Corrosion - types, mechanisms, evaluation of corroded bridges, Fatigue - steel bridges, concrete bridges, Rehabilitation of bridges.

CV-7102 Mechanics of Solids

Introduction to Cartesian tensors; stress tensor and tensorial transformation of stress; Mohr's circle for 3-D stress transformation; dyadic and indicial symbols; finite and infinitesimal strain tensors; Mohr's circle for 3-D strain; constitutive equations for anisotropic material; composite laminates; two dimensional theories of yield; Airy's stress function in plane elasticity; generalized Fourier series solution to bi-harmonic equation; elasticity in polar coordinates; thermoelectricity; numerical methods in elasticity.

CV-7103 Advanced Structural Analysis

Matrix algebra, solution of equations, review of energy principles, virtual work; degree of redundancy, choice of redundant, flexibility method, kinematics indeterminacy, development of element stiffness matrices, stiffness method of analysis of structures, computer applications and software development, axial force effects and Eigen value analysis, introduction to finite element method, introduction to structural stability. Development of software in C++ language.

CV-7105 Finite Element Methods

Basic concepts of structural modelling, Review of the Stiffness method of Structural Analysis, Modelling stiffness, loads and dis-

placement boundary conditions, Mathematical interpretation of finite elements, variational formulation, Formulation of Finite Elements- development of continuum elements, shape functions consistent loads, numerical integration, convergence requirements, Computer Implementation of the Finite Element Method- Pre-processing: model definition, element level calculations, equation assembly, equation solver.

CV-7107 Advanced Steel Design

Introduction of Steel Structures- material behaviour, member and structural behaviour, loads, connections, design of steel structures, Basic Stability Theory- potential energy and strain energy, buckling of one degree of freedom, Stability of Steel Beams- Elastic buckling under axial loading, elastic torsional buckling, elastic lateral buckling, design against buckling, Stability of Steel Plates and Shells- theory of plate bending, elastic buckling of plates and shells, Fatigue Design of Steel Structures- S-N curves, fatigue crack propagation, fatigue category, fatigue life estimate.

CV-7110 Plates and Shells

Pure bending of plates (Kirchhoff theory), Rectangular, circular and annular plates under lateral loads, Various edge conditions, Effect of transverse shear deformation (Mindlin theory), Large deflection of Plates, Theory of thin curved shells, Deformation and stresses of cylindrical and conical shells.

CV-7113 Advanced Concrete Technology

Characteristics and properties of constituents of concrete; Cement, Aggregates, Admixtures, etc. and their influence on properties and behavior of fresh and hardened concrete ; testing of properties of concrete and its constituents, performance and durability of concrete; strength development, deterioration vis-à-vis environment; assessment of causes and mechanism of deterioration of concrete with emphasis on some well-known causes, non-destructive testing (NDT), Design of concrete mixes; high performance concrete, light weight concrete, Self-compacting Concrete, Ready mixed concrete .

CV-6201 Applied Soil Mechanics

Mechanical Analysis, Index Properties and Soil Classifications: Principle of sedimentation; sieve and sub-sieve analysis, Pre-treatment of soils, Index Properties, Casagrande's Plasticity Chart, unified soil classification, Relative density of sand.

Effective Stress Principle and Permeability: Terzaghi's effective stress principle, Flow through soils and Darcy's Law, Constant and falling head permeability, In-situ permeability, theory, wells.

Stress-History and Compressibility of Soils: Normally consolidated and over-consolidated soils, pre-consolidation pressure, Terzaghi's theory of consolidation, Pore pressure coefficients, Skempton & Bjerrum Modification, Secondary consolidation.

Stress Distribution in Soils: Evaluation of geo-static stresses, Mohr's circle of stresses, Elastic theories for evaluation of stress increments.

Stress-Strain Behaviour and Shear Strength: Stress and strain conditions in plane shear and axi-symmetric conditions, Direct shear and triaxial tests, Stress-strain behaviour of cohesive and non-cohesive soils, Shear strength of cohesive and non-cohesive soils, Stress path methods and stress-strain theories.

CV-6203 Foundation Engineering & Design

Principles of Foundation Engineering: Design of foundations, Design criteria: allowable settlement, total factor of safety, partial factors.
Stability Analysis based on plastic theorem: Total and effective stress analyses, Limit analysis: upper bound and lower bound calculation, Slip line method, Limit equilibrium method.
Earth Pressure Problems Related to Foundation Engineering: Earth pressure and earth pressure coefficient, Earth pressure at rest, active and passive pressure, Earth pressure acting on flexible walls, Case histories.
Shallow Foundations: Types of shallow foundation, bearing capacity Calculation: bearing capacity factors: Factors affecting bearing capacity: 2D and 3D, depth, load inclination and eccentricity, foundation flexibility, soil compressibility, Stress in elastic media due to surface loading, Settlement calculation: immediate settlement, consolidation settlement, Settlement predictions using in-situ tests and empirical methods, Case histories.
Deep Foundation: Classification of deep foundations, types of pile foundation, Load transfer mechanism: friction resistance, pile tip bearing load, Vertical bearing capacity and settlement of piles, Time effects, group action of piles, negative skin friction, Lateral loads on piles, pile testing, Case histories.

CV-6205 Geology for Civil Engineers

Geological and Mechanical Principles: Geological time, Rock forming minerals, Rock types, Soil Types, Mechanical fundamentals for Engineering Geology, Soil and rock properties.
Geological Structure Analysis: Geological structures (faults, folds), Discontinuities, Hemispherical projection (basics and borehole analysis). Processes in Engineering Geology: Weathering, Erosion, transportation and sedimentation, Groundwater.
Applied Engineering Geology: Landslides classification for slopes in rock and soil, Mass movement in rock, Mass movement in soil, Excavation Principles in Rock and Soil. Engineering Geology in Practice: Site characterization and investigation techniques, Case histories and examples, reporting.

CV -6207 Soil Dynamics & Earthquake Engineering

Fundamentals of Vibration: Fundamental definitions, System with a single degree of freedom, System with two degrees of freedom.
Waves in Elastic Medium: Elastic stress waves in a bar, Stress waves in an infinite elastic medium, Stress waves in elastic half-space.
Properties of Dynamically Loaded Soils: Laboratory tests and results, Field test measurements, Correlations for shear modulus and damping ratio .Foundation Vibration: Vertical, rocking, and sliding vibrations of foundations, Vibration of embedded foundations, Vibration screening. Dynamic Bearing Capacity of Shallow Foundations: Ultimate dynamic bearing capacity, behaviour under transient load.
Earthquake and Ground Vibration: Earthquake magnitude, Vibration of soil layers due to earthquake, Characteristics of rock motion during earthquake.
Lateral Earth Pressure on Retaining Walls: Mononobe-Okabe active earth pressure, Laboratory model test results for active earth pressure coefficient, Design of gravity retaining walls based on limited displacement, Passive force on retaining wall.

Compressibility of Soils under Dynamic Loads: Compaction of granular soils, Settlement of foundation on granular soil under vibration. Liquefaction of Soil: Fundamental concept of liquefaction, Laboratory studies to simulate field conditions for soil liquefaction, Procedures for determination of field liquefaction.
Seismic Stability of Earth Embankments: Free vibration of earth embankment, Forced vibration of earth embankment, Pseudo-static analysis, Estimation of Earthquake-induced deformation.

CV-6208 Pavement Design
Introduction to pavement design process, concepts, history and design factors, stress-strain analysis for flexible pavements, stresses and deflections in rigid concrete pavements, analysis of traffic loads, material consideration in design, factors effecting design, service ability concept and failure criteria of rigid and flexible pavement, AASHTO design method for rigid and flexible pavements, pavement evaluation, rehabilitation and overlay design.

CV-6209 Geotechnical & Geo Environmental Engineering
Introduction: Waste characteristic, Landfill system. Clay Mineralogy: Basic structural unit, Two-layer sheet and three-layer sheet, Classification of clay minerals and their characteristics, Double layer theory. Leachate: Definition of leachate, Leachate characteristic. Soil-Leach- ate Compatibility: Soil-solution interaction, Soil-hydrocarbon inter- action, Role of surfactant. Method for Assessing Hydraulic Conductivity: Laboratory tests for determination of hydraulic conductivity
i.e. fixed wall test and flexible wall test, Field tests for determination of hydraulic conductivity i.e. variable head test, constant head test and pumping test. Flow through Porous Media: 1-D flow, 2-D flow. Conduction of Chemical Species through Porous Media: Steady state diffusion, Transient state diffusion, Column test, Batch equilibrium test. Cover System of Landfill: Type of cover system, Components of cover system, Design of cover system. Settlement of Landfill: Creep models, Prediction and quantification, Case studies. Gas from Landfill: Landfill gas characteristic, Landfill gas movements, Landfill gas control. Water Balance in Landfill: Design of drainage systems. Landfill Monitoring and Control: Drilling method, Soil sampling method, Groundwater sampling method, Landfill monitoring scheme. Site Remediation Technology: In-situ site remediation technique, Ex-situ site remediation technique.

CV-6210 Underground Excavating & Tunneling
Introduction: History, type, stability and influencing factors, related problems.
Underground Excavations in Rocks: Stresses and displacements around underground excavations, In situ stresses, Thick-walled cylinder solution, stresses and displacements around a circular opening, uniform stress field & non-uniform stress field (elastic, elastoplastic), ground reaction curves (characteristic lines), Displacements around advancing tunnel face, Elastic stresses and displacements around non-circular openings and caverns; around multiple excavations, Design considerations for underground rock excavation on the basis of stress criteria; pressure tunnels, Tunnel responses and relation to ground properties and geology, Stand-up time and free span, Type of tunnel grounds: rock and soft ground, Major ground responses: rock burst, loosening, squeezing. Methods of excavation and support, Conventional method (drill-and-blast with steel sup- port), Mechanized tunneling & tunnel boring machines (TBM's),

Supports (initial & final supports): steel ribs, rock bolts, and shot-crete. Methods of excavation, ground treatments and supports for heavy grounds, Geotechnical investigations for design and construction, Determination of rock loads on tunnel support requirements, Empirical methods (Classifications: Terzaghi's, Deere's, Barton's, Bieniawski's, NATM, etc.).

Analytical methods - confinement-convergence method. Numerical methods - stress and displacement analysis. Observational methods - control criteria/back analysis. Instrumentations, purposes, types of measurements and interpretation, New Austrian tunnelling method (NATM).

Soft Ground Tunnelling: Types of ground responses and influencing factors, Face stability in clay and granular soils, Shield tunnelling, Ground movement prediction (empirical & numerical analyses), Response of structures to ground movement from tunnelling, shallow foundation, piled foundation, damage criteria, risk assessment, Con- trol of stability and ground movements: compressed air; ground treatment (grouting, dewatering, freezing, etc.), Lining design: lining load, ground-lining interaction, segmented lining, analysis methods. Instrumentation and Monitoring.

CV-6212 Pressure & Retaining Systems

Pressure on Retaining walls. Basic concepts and earth pressure theories. Design criteria and pressure analysis of rigid walls with and without surcharge loads. Effect of seepage and drainage on walls. Pile – supported retaining wall. Behaviour of flexible earth retaining structures. Design criteria and pressure analysis of anchored bulk heads, braced out and tie back bracing system, design criteria for cellular cofferdams. Behaviour of retaining walls during earthquakes.

CV-7202 Advanced Methods in Geotechnical Engineering

Introduction to slope stability studies, Slop stability analysis, Design and construction of soil reinforcement. Bearing capacity of reinforced earth. Reinforced earth walls and slopes. Characterizing cohesion sands – Review factors, affecting strength, sampling and test- ing, In situ tests, static and seismic loading behaviour, characterizing saturated clays- Review factors affecting strength, sampling and testing, In situ tests, static and seismic loading behaviour, representation of strength in slope Stability Analysis, Slope in other Materials-stiff fissured clay, sensitive clay, partially saturated clay, loess, residual soils, rock slopes landfill liners. Site investigation methods ground water flow: methods, control and design of dewatering systems. Ground support techniques during temporary works. Analysis of soil improvement techniques including grouting, vertical drains, and dynamic compaction.

CV-7204 Advanced Analytical Geotechnical Engineering

Field Testing Equipment and Data Interpretation: Sampling, Standard Penetration Test, Field Vane, Cone Penetration & Dissipation Tests, Pressure meter, Dilatometer. Field Monitoring Equipment: Piezometer, Inclinometer, Settlement Measurements.

Advanced Laboratory Equipment: Consolidation, Constant rate of strain/displacement, Rowe Cell & Radial flow, Ko consolidated Triaxial, Measurement of Ko-value, Strength testing, Ko-consolidated Tri- axial (Compression & Extension), Direct Shear and Simple Shear, True Triaxial & Plane Strain, Torsional Shear Hollow Cylinder, Directional Shear Cell.

CV-7206 Ground Improvement Techniques & Geo Synthetics

Densification and Consolidation: Shallow and Deep Foundations, Dynamic consolidation and vibroflotation. Preloading and Drainage: Vertical drain with surcharge and vacuum preloading, Electro-osmotic consolidation with vertical drains. Soil Reinforcement: Rein-forced earth and geotextiles applications, Granular piles/sand compaction piles. Soil Stabilization by Admixtures: Soil + cement (deep mixing method), Soil + lime (lime columns) and other additives. De- signing with Geosynthetics: Composition, Properties and Functions of Geosynthetics, Designing for Separation, Filtration, Drainage and Roadway Applications, Designing for Landfill Liners and Barrier Applications.

CV-7211 Rock Mechanics

Rock Engineering in Geotechnical Practice: Overview of rock mechanics and rock engineering, Application to civil and mining engineering. Properties of Intact Rock, Rock Mass and Geologic Discontinuities: Index properties and classifications for rocks, Geologic dis- continuities and description, In situ stresses and measurement, Stress-strain relationship, brittle fracturing and failure theories, Strength criteria of rock and rock mass, Properties of weak rock - creep, swelling, slaking. Deformability of Rock Mass: Types of problems - buildings, dams, pressure tunnels, Influencing factors and theoretical assessment, Determination of modulus of rock mass (laboratory tests, in situ tests, empirical methods), Elastic solutions for stresses and displacements beneath foundations and around tunnels (close-formed and numerical analysis).

Groundwater Flow in Rock Mass and Assessment: Flow characteristics, Permeability measurements and flow analysis and monitoring.

Foundations on Rocks: Modes of bearing capacity failure, Socketted pile foundations, Foundation on weathered rock, Foundation on karstic terrain. Rock Slope Engineering: Types of slope movement and influencing factors, Classification of slope movement and land-slides, Failures of rock slopes, Failures of weathered rock/residual soil slopes, Shear strength along geologic discontinuities, Influence of irregularity, displacement, joint filling and confining pressure, Strength criteria (Patton's, Barton's, etc), Rock Slope stability analysis, Plane failure, Wedge failure, Rotational failure, Rock falls, Application of software for rock slope analysis, Stabilization and instrumentation.

CV-6301 Development of Transport Infra-Structure

Transportation & access needs of the society, various modes of transportation systems (e.g. road and rail), passenger and freight movements, basic considerations of transport infrastructure developments, current development programmes, Integration of transportation systems, interface between systems, National & Global Transportation Networks. Appraisal & Evaluation of Transportation Projects; Appraisal & evaluation guidelines, Requirements, Method- ology, Other considerations and practical examples, Highway Planning, Design & Construction; General planning considerations, Components & Classification of highways, Design elements and standards, Loading on pavements, Design principles for flexible and rigid pavements, Construction & Maintenance of modern highways. Rail- way Systems; Important components of the railway system, Railway development, Railway capacity, Railway alignment, Rail joints, bal- last and other infrastructure components, Airports and Sea ports; Airport activity systems & components, Airport planning procedure,

Runway orientation, Runway length and pavement design, Design of port terminals & connections, Seaport activity systems & components, Seaport planning procedure, Port and Airport Development Study (PADS).

CV-6302 Urban Transportation Planning and Development

Coordination of City Planning and Transportation Planning. Trip generation, trip distribution, modal split, trip assignment models; Pre- paring land-use cum transport plans; Economic evaluation; Urban travel Characteristics and trends in travel demand. Basic urban transportation studies i/c origin destination surveys, Inventory use studies, Parking studies and transit surveys. Pedestrian facilities; Light rail and Mass Rapid Transit.

CV-6002 Probability and Statistics

Probability: Concepts of Probability and their relevance to statistical analysis, Probability distributions relevant to transportation data analysis. Data Collection: Survey planning and design, traffic survey practice, inventory surveys, transport usage surveys, travel time and congestion surveys, matrix surveys, questionnaires and interviews, sources and use of secondary data, Statistics: Summary measures. Statistical distributions, confidence intervals, hypothesis testing, contingency table, correlation and linear regression analysis, ANOVA and multivariate analysis.

CV-6305 Geometric Design of Highway

Design philosophy and present trends, Design controls and criteria, Design speed, Safe sight distance, Road gradients, Super elevation, Capacity as design control, Horizontal and Vertical alignment, Cross-section, Speed, Change lanes, Medians, Design of At-grade and grade separated intersections, Road-rail crossings, Highway drainage, De-sign automation concepts, and Highway design software.

CV-6307 Transport and Logistics Management

The Transport System; The function of transport; the elements of transport system; systems concept as applied to transport and distribution. The Structure and Management of Transport Organisations; The pattern of ownership and scale of operation; organisation structures; management function and practices; policy formulation and planning of strategies. Road Transport Management; Highway Classification; Area Traffic Control; Parking Control; Junction Control; Traffic Surveillance And Regulations; Transport Routing Management. Pavement Management System; Maintenance Assessment Rating and Costing for Highways; pavement maintenance and rehabilitation strategy; pavement performance prediction; economic analysis and network optimization. Logistics Management; Concept of a logistics system, Logistics need evaluation, Design & management of logistic & distribution networks, Optimal vehicle fleet utilization techniques, Industrial logistics, Stores, spares & supplies management, Warehousing, Logistic operations for emergencies & relief operations, Training & Scheduling.

CV-6509 Highway Materials

Properties and usage of soil, sand and rock as highway materials, Modification and evaluation of their properties, Criteria for use and acceptance, Testing, variability and quality control, use of non-structural material, material resources, in-service conditions, and their ef-

fect on material, performance, properties and use of bitumen, asphalt & tars and concrete as pavement materials. Rheology of bitumen, bituminous coating of aggregates, optimization of bituminous mixtures, Asphalt Concrete mix design. Quality control and performance of bituminous & concrete pavement materials.

CV-6310 Transport Economics

Introduction to transport economics, Demand for transport, Transport supply, Transport pricing Subsidy and investment, Competition and ownership, Cost benefit analysis in developed countries, Cost benefit analysis in developing countries, Road user charging, Transport and the economy.

CV-6311 Public Transport Operations and Management

Overall Framework; Public transport operations and planning process; Problem decomposition. Tradeoffs between services; Standard versus mini-vehicle; Vehicle size models. Public transport planning studies. Data Collection Methods; Manual and automated data col- lection techniques; Automatic vehicle monitoring; Sampling considerations; Operations surveys: passenger load counts, boarding and alighting checks, transit speed and delay studies. Frequency and Headway Determination; Analyzing passenger load and running time data, Four methods for frequency and headway determination. Examples of the four methods and cost-effectiveness criteria. Timetable Development; Current practice, Alternative timetables, Timetables with evenly spaced headways, Timetables with even loads. Automated timetables with examples, Experiences with computer pro- grams. Vehicle Scheduling; An experience with an optimization scheduling method, Graphical and optimal method for an interactive system, Fixed and variable schedules, Minimum fleet size, Dead-heading considerations. Service Reliability; Variability of concern to passengers and operator, The bunching phenomenon, Improving re-liability, Passenger waiting time, Vehicle Running time; AVL (automatic vehicle location) systems-features and benefits. Systems Analysis; Recent developments, Production functions and marginal analysis; Sensitivity analysis; Resource allocation and transportation problems. Transit Network (Routes) Design; Current practices, Establishing objective functions, Creating routes and transfers, Demand assignment and initial frequency determination, Optimal criteria and best solutions with flexibility for decision makers. Design & Evaluation of Public Transport Priority Measures; Important elements in providing preference to public transport, Priority schemes, Design and Evaluation. Applications of information technologies in public transport. Field/Laboratory Work; Public transport network building and demand assignment, boarding and alighting counts, on-board surveys, and on-site case studies.

CV-7303 Advanced Traffic Engineering and Management

Road inventory, Traffic measurements, flow, speed, roadstructures, driver, vehicle & pedestrian characteristic; Controlled & uncontrolled intersections; Signals, Street lights, road markings, traffic signs. One way and Tidal Flow System, Parking Controls, Traffic calming; Capacity Analysis of signalized and un-signalized intersections; Accident study and road safety; Intelligent Transport System, Travel Demand Management.

CV-7304 Pavement Analysis and Design

Pavement type, stress distribution in pavements; theoretical and actual sub-grade conditions & traffic loading, design principles, methods & criteria for flexible pavements, rigid & semi-rigid pavements. Design of special duty & temporary pavements; Environmental influences & effects, pavement overlays, Mechanistic Design of Pavements, Pavement sub-drainage.

CV-6306 Sustainable Transportation Systems

Introduction & emerging need for sustainable transportation systems, Sustainable transport Indicators, Sustainability Analysis of transportation systems with special focus on developing countries like Pakistan, Policy issues and main principles of design, Application of advanced transport technology and intelligent transport systems.

CV-7308 Intelligent Transportation Systems

Introduction to intelligent transportation systems, Basic types and application areas, Design & Performance Characteristics, World wide applications, and ongoing research, Accident prevention, Environ- mental pollution control and other main advantages.

CV-7312 Supply Chain Management

Concepts in supply chain management; Information technology for the supply chain; Decision support system for supply chain management; Logistics network design and planning; Inventory management in the supply chain; Risk pooling concept; Bullwhip effect in supply chain; Computerized beer game; Supply chain integration; Strategic alliance and partnering; Product and process design for logistics; International issues in supply chain management.

CV-7401 Project Management

Introduction to Project Management - Goals, Roles and Responsibilities, Project life Cycle, Role of Project Manager, Project Selection Models, Project Acquisition and Risk Analysis, Project Scope Management, Time Cost and Quality Management, Project management Software, Project Communications, project Team Building, Project teams and Teamwork Issues, Project Termination Issues.

CV-7402 Total Quality Management

Introduction to quality (definitions, history and importance, dimensions), Principles of Total Quality Management, TQM as a new culture, Quality management philosophies (Deming, Juran, Crosby, Ishikawa, Taguchi, Feigenbaum), Customer satisfaction and customer relationship management, Quality awards (Deming, EFQM, Malcolm Baldridge), Benchmarking, Tools for TQM (quality improvement, SPC, QFD, Taguchi, techniques, etc.), Quality standards and quality assurance systems, Cost of quality.

CV-7404 Construction and Industrial Law

Introduction, Role of Engineers and managers, Ethics and Professional Status, Business Issues- Business Organizations, Law of Con- tract, Intellectual Property Law, Employment, Liability Issues- Law of Tort, Risk and Loss Management, Bonds and Insurance, Societal Responsibilities- Environmental Law and Considerations, Health and Safety Act, Sustainable Development, Employment Equity and Hu- man Rights, Career Issues – Leadership and Management, The Engineering Design Process- Design for Safety, Quality Assurance.

CV-7406 Statistics and Probability

Introduction to Basic Elements of Probability Theory, Important Probability Distributions in Engineering- Gaussian, log-normal, binomial, exponential, Poisson, exact and asymptotic distributions of extremes, Emphasis on applications to various engineering problems, Component and System Reliability/Failure Analysis-time to failure, failure rate, hazard rate, hazard function, reliability of series system configuration, reliability of parallel system configuration, reliability of r-out-of-n system configuration, Elements of Decision Analysis Un- der Uncertainty- simple and more general risk decision problems, decision tree, decision criteria, maximum expected monetary value criterion, optimal alternative.

CV-7407 Infrastructure Management in Public Sector

Definition of public infrastructure, Infrastructure management process- monitoring and evaluation, planning and programming, design, construction, operations and maintenance, Infrastructure Organizations and Systems- role of Local, regional, state, and federal agencies, their organization and relationships. Managing infrastructure within and between large public agencies, role of civic organizations and the private sector, planning, design, and construction management consultants.

Infrastructure systems: Streets, highways, and sidewalks; public transportation; street lighting and traffic control systems; potable water supply; wastewater and drainage, parks, recreation facilities, and public open spaces; communications systems; public buildings; solid waste handling and disposal, Infrastructure Monitoring and Evaluation, Infrastructure Planning-Principles and practices of infra-structure planning, Infrastructure Programming and Budgeting, Project Development – infrastructure design, identification of barriers to project development, realistic project schedule and budget. Role of value engineering, Environmental Impact Assessment, Construction- bidding and contract award process, Construction inspection with and without a construction management consultant. Quality Assurance in the construction product.

CV-7408 Human Resource Management in Construction Projects

Importance of HRM, external factors influencing HRM; planning and forecasting human resource requirements; recruitment and selection; performance management; reward systems; careers and mentoring; HRM outcomes and current issues in HM. Effects of sociological, legal, economic, ethical, political, strategic and environmental changes, issues and developments on human resource management processes, practices, programs and policies. Responsibilities of HR managers- strategic implementation, managing change, international employment relations, corporate restructuring initiatives, and employee information management, Legal constraints in HR planning

CV-7403 Construction Operations and Productivity

Lean construction principles; materials management including procurement and control; process simulation and flow improvement; constructability, subcontractor and supplier management; quality and productivity improvement; just-in-time, just-in-case, and just- right delivery practices; bar coding for material identification; and construction facilities and site development.

CV-7405 Management of Design Process

Design Team Organization, Problem Definition Understanding, De- sign Process Overview, Schematic Design, Concept Design Develoment, Final Design, Ready to Advertise Construction Documents , Disruption Management/Phasing, Schedule Monitoring, Project Management Meetings, Construction Team Organization/Plan, Inspection & Testing/Surveillance, Computer applications/tools, Parking, Security, Outages, Interim Moves, Relations between Contractor and Others, Mock-ups, Relationship to space plan and building de- sign/construction, Budgets, Re-use criteria/analysis and refurbishment, Managing the moving target of technology, Process/phases, User review/approval, Computer Applications/Tools, A/E Relation- ship

CV-7409 Sustainability and the Built Environment

Fundamental concepts of sustainability and sustainable development, natural systems, interaction of the built environment (infra- structure) with natural systems, Role of technical and non-technical (economic, social, ecological, ethical, philosophical, political, psycho- logical, cultural) issues in shaping engineering decisions, System science and system thinking, Methods to identify and select sustainable solutions to design problems, Methods of improving existing solutions; and methods of reasoning, Natural building technologies and Alternative building systems. Eco-materials, sustainable water and waste water systems, renewable energy, waste and waste products, green building construction, straw bale construction, natural plasters, and building with earth and straw.

CV-7410 Information Technology Applications

Introduction and overview of technology applications for civil and environmental engineering, choice of tools and software, simulation and modelling, Intelligent transportation systems overview including environmental and energy savings concepts, Introduction to Remote sensing and cartography, photogrammetry, Introduction to GIS- data base system, GPS, Spatial data visualization, Computer aided design, computer graphics.

CV-6501 Environmental Engineering Design

Design Principles for water, wastewater and solid waste processing, Water treatment Plant design, Municipal wastewater treatment Plant design, Sludge and biosolids, Industrial wastewater, Municipal Solid waste management and disposal, Air Quality Criteria / Management.

CV-6502 Water and Wastewater Engineering

Water quality and standards, Sources of contamination; Treatment of water, Clarification, Design of Clarifier / Sedimentation tank, Sedimentation of flocculent suspensions, Hindered settling, Scouring; Coagulation processes, Flocculation processes, Chemical feeding methods, Sedimentation basin design, Selection of mechanical equipment. Filtration of water, Slow and Rapid sand filters, Operating difficulties, other filtration processes. Disinfection. Advanced water treatment techniques; Aeration, Water softening, Stabilisation, Ion Exchange, Reverse Osmosis, Treatment of brackish / saline waters, and Water treatment wastes. Types of wastewaters, Sewage and its characteristics, Microbiology of sewage, Sewage treatment.

Preliminary treatment; Screening, Comminution, Grit and Grease removal, Pre-aeration, Equalization, Primary treatment; Primary sedimentation, Chemical coagulation, Fine screening. Secondary treatment; Attached growth processes; Design of Trickling Filters, Design of Rotating Biological Contactors, Design of Fluidized Bed Systems, Design of clarifier, Suspended growth processes; Activated Sludge, Lagoons and Oxidation ponds, Aeration and mixing techniques, De- sign of clarifier for suspended growth process. Sludge management, its amount and characteristics. Sludge conditioning, Digestion, Processing and Disposal, Composting. Advanced wastewater treatment; Purpose, Suspended Solids removal, Removal of Nitrogen, Phosphorus, Refractory organics and Dissolved Solids. Disinfection, Odour control.

CV-6504 Solid Waste Management

Evolution of Solid Waste Management; Sources, Composition and Properties of Solid Waste, Municipal Solid Waste, Physical, Chemical and Biological properties of MSW; Types of Hazardous wastesfound in MSW. Solid waste generation and collection rates, Waste handling and separation, storage and processing, Collection, Transfer and Transport, Recovery, Reuse and Recycling, Disposal of Solid wastes and residual matter. Sanitary Landfills, Incineration and other methods of safe disposal.

CV-6506 Environmental Management Techniques

Environmental Organization, Legislation, Standards, Monitoring and Compliance assurance, Environmental Economics, Regional Development Planning, Environmental Decision Making for industries, NEQs, ISO- 14000 and Occupational Safety and Hazard Regulations, Risk Analysis.

CV-6509 Marine and Estuarine Environment

Marine Ecology, Effects of Pollution Discharges, Oil Spills, Coast Development, Beach Erosion, Channel Dredging and Changing Sea-Level on Marine Environment and Control Measures, Modeling for Pollution Dispersion, Study of Marine Biology (Organism, Fisheries and Mangroves), Coastal Geology and Estuarine Ecology. Marine Resources Management

CV-6510 Environmental Measurements

Principle of Analysis Related to Important Areas in Environmental Chemistry. Analytical Techniques include Colorimetry, Gravimetric and Electrochemical Methods, Atomic Absorption Spectrophotometer, and Gas Chromatography for Determination of Physical/ Chemical Characteristics of Water, Wastewater, Solid and Air. Analysis of Treatment Parameters Used in Monitoring of Biological Processes, Microbiological Examinations of Water and Wastewater. Toxicity Tests for Aquatic Organisms.

CV-6511 Water Quality Management

Introduction to Water Quality Management, Eco-toxicology, Bio-monitoring and Environmental water quality, Aquatic Toxicology. Water Laws and Regulation and Strategies for Wastewater and Water Quality Management. Direct Estimation of Ecological Effect Potential. Water resources Hydrology and Geo-hydrology, Basic Water Microbiology and Chemistry, Biological, chemical and physical water quality parameters. Point and diffuse sources of pollution.

CV-6512 Disaster Management and Risk Analysis

Disaster Risk Context, Terms and concepts used in disaster management, Evolution of disaster risk management, Disaster management models and approaches, Disaster risk management process; Hazards, Vulnerability factors, Coping capacities, Outputs from risk assessment. Prevention / Mitigation; Framework for prevention and mitigation, Structural mitigation, Role of public awareness, Preparation of prevention and mitigation strategies. Preparedness Planning, Key preparedness considerations; Coordination and the emergency coordination center, Early warning systems, Damage assessment and needs analysis, working with the media. Emergency Response Management System; Damage assessment and needs analysis, Information management, Resource management. Recovery and Reconstruction.

CV-7503 Air Pollution and Control

Introduction to Air Pollution Control, Air Pollution Effects, Air Pollution Measurements, Emission Estimates, Meteorology, Air Pollutant Concentration Models, General ideas in Air Pollution Control, Nature of Particulate Pollutants, Control of Primary Particulates, Control VOCs, Sulphur dioxide, Nitrogen oxides. Control of Industrial emissions. Motor vehicle problems. Air Pollutants and Global Climate, In- door Pollution.

CV-7505 Environmental Impact Assessment

Introduction to Environmental Impact Assessment, Overall EIA process; Preliminary Assessment, Scoping, Identification of Impacts, Quantification of Impacts, Mitigation Measure, Presentation of EIA, Decision making, EIA Guidelines for various developmental projects in different sectors. Case Studies.

CV-7507 Environmental Auditing

Introduction to Environmental Audit, Eco-design, Supply Chain Management, Quantifying and reporting environmental performance, Relationship and difference between ISO 14001, ISO 9000, EMAS & TQM, Life cycle analysis (L.C.A.). Audit skills and process, Overview of auditing, Types of audit, Basic audit process. Environmental Legislation and Auditing Skills, Evaluating audit results, Audit reporting, Post-audit activities.

CV-7508 Industrial and Hazardous Waste Management

Evaluation of Industrial Waste Problems, Legislation, Characteristics, of wastes produced from industries, Application of Engineering Principles and Processes for Pollution Prevention, Waste Treatment, Recovery and Disposal, Integrated Municipal Solid Waste Management Practices combined with Hazardous Waste Management, Site Remediation Technologies-Bioremediation, Air Stripping and Vapor Ex- traction.

Computer Engineering Courses

CE-6099 MS Thesis
The thesis is a report of theoretical or laboratory/practical work, suitable for publication. The Department will appoint an MS Thesis Supervisor for this purpose. The student will choose a suitable topic with the approval of the Supervisor who will guide, supervise and monitor the student's progress and suggest reading material.

CE-6103 Networking Protocols
Fundamentals of computer networks and the Internet. Protocol layers and their service models. Application layer services and proto- cols, DHCP, DNS, HTTP, Email protocols. Transport layer services and protocols, reliability, congestion control, UDP, TCP, SCTP. Network layer services and protocols, ARP, IPv4, IPv6, ICMPv6. Link layer ser- vices and protocols, error control, link control and link virtualization.

CE-6104 Internetworking
Overview of TCP/IP protocols and network technologies; Internetworking concepts and architectural model; Switching technology, switch components, LAN switching, WAN switching, spanning tree; Internet addressing with IPv4 and IPv6; Routing architecture, distance-vector routing, link-state routing, inter-domain routing, intra- domain routing; Label switching, flows, MPLS; Packet classification; Virtual LANs, virtual private networks, network address translation; Multicasting, Ethernet multicast, IP multicast, multicast addressing, multicast routing.

CE-6109 Network Performance Evaluation
Techniques for analysing the performance of networks and computer systems. The techniques to be covered include statistical analysis of measurements, queuing theory and simulation. The applications and limitations of each technique will be studied. Design and implementation of simulations of discrete event systems. Topics include simulation models, a review of relevant concepts in probability modelling and statistics, queuing theory, generation of random numbers and variates, variance reduction techniques, analysis and validation of data and results, and comparison of simulation languages. Emphasis will be placed on applying these techniques to performance-capacity modelling and analysis of computer and communications systems. Students will be expected to implement a simulation project.

CE-6110 Networks and Optical Communication
Fundamentals of Optical Communication, Optical Components and Fiber Classification, Fiber Distributed Data Interface (FDDI) Architecture, Extension for Telecommunication: FDDI-II, TCP/IP and OSI Protocols on FDDI, SONET/SDH Architecture, Design Configuration of SONET/SDH, SONET Automated Protection Switching (APS) Technology, TCP/IP and Protocols and SONET/SDH, Dense Wavelength Division Multiplexing (DWDM) Technology, Optical Communication Systems Design, Optical Network Design.

CE-6111 Programming for Internetworking Applications
Introduction and Overview, The Client/Server Model and Software Design, Applications using the TCP/IP Protocol Suite, Program Interface to Protocols and the Socket Interface Design, Algorithms and

Design Issue of Client/Server Software, Servers Classification, Remote Procedure Call Concept, Introduction to Transport Level Interface, Distributed Program Generation.

CE-6112 Stochastic Process Engineering

Probability and random variables, characteristic functions, transformation of random variables, sequences of random variables, linear mean squared estimation, stationary estimation, stationary random process, correlation functions power spectrum output of linear systems with stochastic input, Gaussian process. Markov chains, state classification, kolmogorov equations, applications to Probabilistic finite state machines, Birth death process, applications to queuing theory, buffer problems and the design of communication nets.

CE-6113 Digital Signal Processing

Introduction, Classification of Signals, Discrete-time Signals, Convolution, Correlation, Fourier Transforms, Discrete Fourier Transform (DFT), Discrete-time Fourier Transform (DTFT), Fourier Transform Properties, z-Transforms, z-Transform Properties, Sampling of Continuous-time Signals, Aliasing, Analog to Digital Conversion, Digital to Analog Conversion, Digital Filters, IIR and FIR Filters, Design of Digital Filters, Application of Digital Signal Processing.

CE-6114 Digital Communications

Introductory topics, Sampling, Aliasing, and Pulse code Modulation and related topics, Baseband Demodulation, Digital Passband Transmission (Modulation / Demodulation), Channel Coding, and Advanced Topics.

CE-6115 Wireless and Mobile Networking

Overview of wireless and mobile communication and networking; wireless personal area networks, Bluetooth, Zigbee; IEEE 802.11 wireless local area networks; wireless regional area networks, IEEE 802.16, cellular networks; mobility management, mobile IPv4, mobile IPv6; mobile ad hoc networks.

CE-6116 Multimedia Networking

This course explains and discusses key concepts of multimedia networking, including basic representation and compression of multimedia data types, characteristics of multimedia, multimedia perceptual quality, multimedia protocols SIP and H.323, multimedia streaming and an overview of current multimedia applications.

CE-6120 IT Project Management

Life cycle view of organizing and managing information technology projects, including project selection, planning, and execution. Methods for managing and controlling project costs, schedules, and scope. Techniques for assessing project risk. Use of popular project management software tools. Application of project management tools and methods to product development, software, and process reengineering projects.

CE-6125 Distributed Applications

Design principles and development methods for internet-based distributed applications. Distributed application architectures, language systems (e.g., Java, ActiveX, PERL, and Java Script). Distributed object standards (e.g., CORBA and COM), and net-focused development methodologies. Focuses on the design, implementation and

management of distributed systems, and involves protocol issues above the network layer of the International Standards Organization (ISO) hierarchy. Topics include naming, security, reliability, resource sharing and remote execution, and sharing information in a distributed system, such as electronic mail, file systems and database.

CE-6126 Network Security

Principles of computer and network security management, policy and technical issues. Discussion of techniques for achieving security in multi-user computer systems and distributed computer systems. Introduction to cryptography and its application to network and operating system security: security threats; secret key and public key cryptographic algorithms; hash functions; digital signatures; authentication systems; security services at network layer; security services at transport layer; security services at application layer; authentication, authorization, accounting (AAA); intrusion detection systems; malicious software.

CE-6127 Electronic Commerce

Electronic commerce: payment protocols, electronic cash. Security on the World Wide Web. This course focuses on the security proto- cols, algorithms and tools needed to support different E and web applications. First half of the course will focus on the security proper- ties required by various E-Commerce applications and how different protocols and techniques satisfy these. In the second half the practical aspects of implementing E-Commerce applications, surveying various emerging technologies is discussed. This part of the course will require students to work in teams on implementation of one or more projects.

CE-6128 Network Management

A range of network management protocols are introduced. The components of network management, i.e., fault management, performance management, configuration management, security management and accounting management. The integration of the components into an enterprise management system is addressed. Students will have access to a laboratory where aspects of network management can be tried out in a practical way.

CE-6204 Software Quality Assurance

Introduction to Software Quality Assurance, Total Quality Management, Software Quality Lessons, Standardization of Software Quality Assurance, SQA Program Management Office, Costing of Quality Assurance, Up-Front Quality Technique, Software Configuration Management, Software Capability and Maturity Model, Software Quality Assurance, CASE Tools, Software Quality Assurance Metrics, Practical Applications of SQA, Software Reliability
Management.

CE-6208 Information Systems Analysis and Design

To analyze the information needs of organizations and design suitable information systems to meet their needs. Topics include: systems analysis and design techniques related to analyzing and determining information needs, feasibility studies, designing input/processing/output systems, and hardware/software development and evaluation.

CE-6209 Formal Methods in Software Engineering

The course covers the different formal mechanisms for specifying, validating and verifying software systems. Topics include: program verification through Hoare's method and Dijkstra's weakest precondition, formal specification via algebraic specifications and abstract model specifications, including initial specification and refinement towards implementation, integration of formal methods with existing programming languages, and the application for formal methods for requirement analysis, testing, safety analysis and object oriented approaches.

CE-6210 Software Reliability and Safety

Importance of reliability for current and future software systems. Safety criteria hazard analysis and risk analysis. Analysis, design, verification and validation of mission and safety critical systems. Safety critical hardware and software. Measurements of reliability (MTTF, MTTR, defects/KLOC). Techniques to increase reliability and safety: Petri nets, formal methods, component reuse, proofs of correctness. Verification and validation, certification. Safety and security.

CE-6211 Advanced Database Systems

Provides an in depth examination of some advanced database technologies. Topics are selected from object relational databases, active databases, distributed databases, parallel databases, deductive databases, fuzzy databases, data warehousing and data mining, spatial and temporal databases, multimedia databases, advanced transaction processing and database security.

CE-6212 Database Security

Security issues in database systems, different security models for databases, trusted database interpretation, security mechanisms for databases, secure database architectures and multilevel secure database systems. Secure transaction processing, statistical database protection, inference problem, integrity models and mechanisms, models for the protection of next generation database systems, commercial multilevel secure database products and research prototypes and security issues in data warehousing and data mining.

CE-6214 User Interface Analysis and Design

Current theory and design techniques concerning how user interface for computer systems should be designed to be easy to learn and use. Focus on cognitive factors, such as the amount of learning required, and the information-processing load imposed on the user. Emphasis will be on integrating multimedia in the user interface.

CE-6215 Software Measurements and Metrics

Introduction to foundations of measurement theory, models of software engineering measurement, software products metrics, software process metrics and measuring management. Measurement theory (overview of software metrics, basics of measurement theory, goal-based framework for software measurement, empirical investigation in software engineering). Software product and process measurements (measuring internal product attributes: size and structure, measuring external product attributes: quality, measuring cost and effort, measuring software reliability, software test metrics, object-oriented metrics) Measurement management.

CE-6233 Fuzzy Systems

Fuzzy Set Theory and Fuzzy Logics, Fuzzy Sets Applications, Fuzzy Controllers (FC), Expert System Theory and Architecture, Advanced Topics.

CE-6241 Software Requirement Engineering

Definition of requirements engineering and role in system development, Fundamental concepts and activities of requirements engineering, Information elicitation techniques, Modeling scenarios. Fundamentals of goal-oriented requirements engineering, Modeling behavioral goals, Modeling quality goals, Goal modeling heuristics, Object modeling for requirements engineering, Object modeling notations, Object modeling heuristics, Identifying objects from goals, Modeling use cases and state machines, Deriving operational requirements from goals, Requirements Specification, Requirements verification and validation. Management of inconsistency and conflict, requirements engineering risks, the role of quality goals in the requirements selection process, Techniques for requirements evaluation, selection and prioritization; Requirements management; Requirements traceability and impact analysis.

CE-6242 Software System Architecture

Definition and overview of software architecture, the architecture business cycle, Understanding and achieving quality attributes, Attribute-driven design, Documenting software architecture, evaluating software, Architecture, Architecture reuse. Life-cycle view of architecture design and analysis methods, The QAW, a method for eliciting critical quality attributes, such as availability, performance, security, interoperability, and modifiability, Architecture Driven Design, Evaluating a software architecture (ATAM, CBAM, ARID), Principles of sound documentation, View types, styles, and views; Advanced concepts such as refinement, context diagrams, variability, software interfaces, and how to document interfaces; Documenting the behavior of software elements and software systems; Choosing relevant views; Building a documentation package

CE-6243 Software System Quality

What Is Software Quality: Quality Assurance, Quality Engineering. SOFTWARE TESTING: Testing: Concepts, Issues, and Techniques, Test Activities, Management, and Automation, Coverage and Usage Testing Based on Checklists and Partitions, Input Domain Partitioning and Boundary Testing, Coverage and Usage Testing Based on Finite-State Machines and Markov Chains, Control Flow, Data Dependency, and Interaction Testing, Testing Techniques: Adaptation, Specialization, and Integration. QUALITY ASSURANCE BEYOND TESTING: Defect Prevention and Process Improvement, Software Inspection, Formal Verification, Fault Tolerance and Failure Containment, Comparing Quality Assurance Techniques and Activities. QUANTIFIABLE QUALITY IM- PROVEMENT: Feedback Loop and Activities for Quantifiable Quality Improvement, Quality Models and Measurements, Defect Classification and Analysis. Risk Identification for Quantifiable Quality Improvement, Software Reliability Engineering. Sample labs and assignments: Use of automated testing tools, Testing of a wide variety of software, Application of a wide variety of testing techniques, Inspecting of software in teams; comparison and analysis of results

CE-6251 Software Engineering Ontologies

Ontology Engineering: Principles, Methods, Tools, and Languages. Using Ontologies in Software Engineering. Development of Ontologies for SWEBOK (Software Engineering Body of Knowledge): Issues and Techniques. Some Ontologies for Software Development: Ontologies for Requirements, Design, Maintenance, Measurements, Use of Ontologies in Domain Oriented Software Development Environments Comparative Study of Semantics Coverage in Ontologies as per SWEBOK, Alignment of Different Available Ontologies. There will be a lot of case studies in this course as assignments.

CE-7104 Research Methodology

Research design, qualitative and quantitative research, sources of data. Data collection procedures, measurement strategies, questionnaire design, interviewing techniques, content analysis. Literature surveys; information
data bases. Research Ethics, Probability testing, inferential statistics, deductive methods and proofs. The use of computers. Evaluating and writing research reports. Development of a research project.

CE-7105 Wavelet Analysis and Applications

One-and two-dimensional Haar, Daubechies, Mallat wavelets etc., Wavelet Transforms and Fast Wavelet Transforms; Applications (Data compression, Image compression, Edge detection, Network traffics, Nuclear engineering medicine etc.); Multiresolution analysis and wavelets, computation and design of wavelets.

CE-7106 Wireless Sensor Network

Introduction and Overview, Sensor Node Architecture, Sensor-Level Energy Management, Wireless Transmission, Medium Access Arbitration, MAC Protocols for Sensor Networks, Network Bootstrapping and Clustering, Data Routing, Node Positioning/Relocation, Sensor Network Security

CE-7107 Cryptography

An Introduction to Cryptography: Simple Substitution ciphers, Divisibility and Greatest Common Divisors, Modular arithmetic, Prime numbers unique factorization, and finite fields, Powers and Primitive roots in finite fields, Cryptography before the Computer age, Symmetric and asymmetric ciphers, Discrete Logarithms and Diffie Hellman, The Chinese remainder theorem, The Pohlig–Hellman algorithm, Rings, quotients, polynomials, and finite fields. Integer Factorization and RSA, Combinatorics, Probability, and Information Theory: Basic principles of counting, The Vigenere cipher, Probability theory, Collision algorithms and meet-in-the-middle attacks, Pollard's ρ method, Information theory, Complexity Theory and P versus NP. Digital Signature: What is a digital Signature? RSA digital signatures, Hash functions, Random numbers and pseudorandom number generators, Zero-knowledge proofs, Secret sharing schemes, Identification schemes, Padding schemes and the random oracle model, Building protocols from cryptographic primitives, Hyper-Elliptic curve cryptography, Quantum computing, Modern symmetric cryptosystems: DES and AES.

CE-7108 Digital Processing of Random Signals

The Structure Of Stationary Processor, Parameter Estimation, Non-parametric Spectrum, Parameter Estimation Theory For Gaussian Processes, Autoregressive Parameter, Moving Average And Arma Parameter Estimation, Adaptive Ar And Aram, High-order Statistical Analysis, Time-frequency Signal Analysis: Linear Transforms, The Short-time Fourier Transform, The Gabber Representation: Elementary Discussion, Thegabor Representation: Advanced Discussion, The Wavelet Transform, Orthonormal Wavelet Bases, Implementation Of Linear Transforms For Discrete-time Signals Time-frequency Sig- nal Analysis: Nonlinear Transforms, The Wigner ville Distribution, The Ambiguity Function, The Choen Class Of Distributions, High-or- der Ambiguity Function, Estimation Using The High-order Ambiguity Functions.

CE-7109 Internet of Things

Introduction of the Internet of Things (IoT), main assumptions and perspectives, IoT device architectures, Operating systems for re-source-constrained devices, Wired and wireless communication technologies for IoT, Ad hoc and Sensor networks, Dynamic routing protocols for ad hoc networks, Communication protocols for IoT, Data processing for IoT, Various applications and Industrial case studies of IoT. Data and Knowledge Management and use of Devices in IoT Technology. Big Data and the Internet of Things.

CE-7110 Cloud Computing

Datacenter Architectures, Cloud Stack, Technology Trends, Consistency, Availability, Partitions, Cluster File Systems, Data-flow Com-putation Frameworks, Key-Value Store and Interactive Query Systems, Big Data in the Clouds, Geographic distributed Storage, Programming Languages for the Cloud, Data Bases in the Cloud, In Memory Frameworks, Google file system, Hadoop file system, Map Reduce, Cloud networking topologies, Traffic Management, Transport Protocol Improvements, Security, Scheduling and Re-source Management in clouds, Software Level Agreements. Cloud Computing Trends & Issues.

CE-7111 Software Defined Networking

Course Outline: fundamentals of software defined networking (SDN) technology and the perspective from different industrial enterprises. API between control plane and data plane of SDN. SDN controller design. SDN abstraction, protocol independent forwarding, compo-sition and trace tree, network update. Various SDN applications e.g. in traffic engineering and wireless networks, SDN virtualization. SDN fault tolerance and security.

CE-7190 Special Topics in Computer Networks-I

Topics will be chosen based on industry trends and requirements.

CE-7191 Special Topics in Computer Networks-Ii

Topics will be chosen based on industry trends and requirements.

CE-7205 Intelligent Systems

Topics include elements of AI, searching techniques, language paradigms, knowledge representation, reference techniques, object-oriented techniques, engineering application of intelligent systems using production rules, fuzzy logic networks. Project work required.

CE-7206 Decision Support and Expert Systems

To study the application of artificial intelligence in building decision support and expert systems for management and other applications. Topics include: fundamentals of artificial intelligence, knowledge representation and knowledge processing, tools for building expert systems and decision support system design.

CE-7290 Special Topics in Software Engineering-I

Topics will be chosen based on industry trends and requirements.

CE-7291 Special Topics in Software Engineering-Ii

Topics will be chosen based on industry trends and requirements.

CE-7295 Case Studies and Projects

Application of the methodologies, tools, and theory of software engineering to produce a specific validated software product. Projects can be faculty generated, self-generated, and/or work related. All projects must be undertaken with one or more students under the supervision of the instructor. Prior to enrollment, a project proposal must be prepared and approved by the instructor and department chair. Standard software engineering documents must be prepared and approved at each phase of the project, and an oral presentation of the project is required. Course includes lectures and case studies.

CE-8001 Computer Vision

The human eye-brain system as a model for computer vision - Image formation: sampling theorem, Fourier transform and Fourier analysis - Image models - Basic image processing: Sampling and quantization, Brightness and color - Histogram operations, Filters and convolution, Frequency domain processing - Edge detection - Boundary and line extraction - Building machines that see: constraints, robustness, in-variance and repeatability - Fundamentals of machine-learning: classification and clustering - Understanding covariance, Eigende composition and PCA - Feature extraction - Interest point detection Segmentation - 2-D Shape representation - Local features - Image matching - Large-scale image search and feature indexing - Under- standing image data and performing classification and recognition - 3D vision systems - Recovering depth from multiple views - Practical examples, including: biometric systems (recognizing people), industrial computer vision, etc.

CE-8002 Optimization Techniques

Introduction to optimisation and optimal decisions. Convexity. Un-constrained optimisation. Constrained optimisation. Management decision formulations. Optimality conditions for constrained problems. Need for unconstrained methods in solving constrained problems, Necessary conditions of unconstrained optimization, Structure methods, Quadratic models, Methods of line search, Steepest de- scent method, Quasi-Newton methods: DFP, BFGS, Conjugate-direction methods:, Methods for sums of squares and nonlinear equations. Linear Programming: Simplex Methods, Duality ii LPP, Transportation problem. Nonlinear programming: Lagrange Multiplier, KKT conditions, Convex programing.

CE-8003 Intelligent Data Analysis and Probabilistic Inference

Probabilistic methods for modelling data and making inferences from it. Bayes' Theorem and Bayesian inference and networks. Bayesian Decision Trees. Evidence and message passing. Probability

propagation and inference in singly connected networks, generating networks from data, and calculating the network accuracy considering highly dependent data and special techniques for exact and approximate inference in these cases. Exact Inference. Data modelling using probability theory and distributions. Gaussian processes for solving regression problems. Probability propagation in Join Trees. Approximate inference techniques including various sampling techniques and variational inference.

CE-8004 Advanced Computer Systems Analysis

This course covers techniques for analysis and comparison of computer systems using measurement, simulation, and queueing models. Common mistakes and how to avoid them, selection of techniques and metrics, art of data presentation, summarizing measured data, comparing systems using sample data. Experimental designs and fractional factorial designs. Simulation, common mistakes in simulations, analysis of simulation results, random number generation, random variate generation, commonly used distributions. Queueing theory, single queues, and queueing networks. Students do a project involving application of these techniques to a problem of their interest.

CE-8090 Advanced Topics in Computer Engineering-I

Selected research topics in computer engineering. Emphasis is on new results or technical publication and emerging areas.

CE-8091 Advanced Topics in Computer Engineering -II

Selected research topics in computer engineering. Emphasis is on new results or technical publication and emerging areas.

CE-8099 PhD Thesis

The PhD thesis is a report of theoretical or laboratory/practical work, suitable for publication, preferably presented also in HEC approved journals/international conferences of repute out of which at least one research paper must be published in an ISI indexed journal (with impact factor) in relevant area as specified by post graduate committee. The University will appoint a PhD Thesis Supervisor (and co-supervisor wherever deemed necessary) for research purpose. The student will choose a suitable topic with the approval of the Supervisor who will guide, supervise and monitor the student's progress and suggest reading material.

Electronic Engineering Courses

EE-6102 Industrial Control Systems

Review of Control system, Architecture of Industrial Automation / Control Systems, PLC (Programmable Logic Controllers): architecture, real-time control I/O layout, I/O types, inter-processor communications, programming. Industrial applications, interlocking, safety, risks, justification. Loop tuning, communications applications, Operator Interfaces, simple operators, terminals, Measurement Systems Characteristics, Data Acquisition Systems, Introduction to Automatic Control, P-I-D Controller and its tuning, feed forward Control Ratio Control, Time Delay Systems and Inverse Response Systems, Special

Control Structures, HMI (Human Machine Interfaces) package software, business system connectivity (SQL), data structures.

EE-6103 Advanced Digital Electronics and Interfacing Techniques
Revision of topics related to Digital Electronics, Advanced Digital Concepts, Logic Families and their Applications. Internal Structure of Logic Families, Complex Digital Circuits, Synchronous Logic, A/D and D/A Conversion, timing diagrams, computer bus systems, programmable logic devices (PLD), and complex circuit debugging using a Logic Analyzer. Standard logic interfacing, Circuit Design Fundamentals for Microprocessors and Microcontroller based Systems, Different Man-machine Interfacing Techniques, Computer based Design and Simulation of Discrete Implementation of Digital Logic, Micro- processor and Microcontroller based Systems.

EE-6104 Electronic Design Automation
Introduction: digital design flow. Verilog: introduction and use in synthesis, modeling combinational and sequential logic, writing test benches. Logic synthesis: multilevel gate level optimization tools, basic concepts of high-level synthesis – partitioning, scheduling, allocation and binding. Testability issues: fault modeling and simulation, test generation, design for testability, built-in self-test. Testing SoC's. Basic Concepts of verification. Physical design automation. Re- view of MOS/CMOS. Fabrication technology. VLSI design styles: full- custom. Standard-cell, gate-array and FPGA. Physical design automation algorithms: floor-planning, placement, routing, compaction, clock and power routing, etc.

EE-6105 Measurement and Calibration of Electronic Systems
Introduction to Instrumentation for Test and Measurement: Systems approach. Standardization and Traceability. Characteristics of Dynamic Measurements: Types of Dynamic data, Periodic, transient and non-periodic (random). Accuracy, Calibration and Error Assessment. Measurement Systems and Instrumentation Electronics: Amplifies and signal conditioners, Avoiding unwanted signals, System Considerations; amplifier to transducer matching, Integrating, differentiating and filters. Digital signal Processing: Generating and processing digital data, Digital analytical techniques, and Recording and readout devices. Data Acquisition and Measurement Environment.

EE-6106 Intelligent Measurements and Instrumentation
Analog and digital instrumentation principles, analog instrumentation blocks, microprocessor concepts, digital instrumentation blocks, bus communications, telemetry systems, instrument systems set- ups, interference reduction, configuration, selection, installation and application.

EE-6107 Advanced Power Electronics
Single phase and three phase AC Voltage controllers. Single phase and three phase Cyclo converters. Thyristor communication techniques. Single phase and three phase inverters. Modulation techniques. DC link and hidden link inverters. Resonant pulse converters. Zero voltage and zero current converters.

EE-6108 Sensors and Systems
Introduction to systems, Discrete and continuous time systems, memory and memory less systems, analysis of linear time invariant

and time variant systems, Time-frequency characterization of systems, independent and dependent systems, Introduction to nonlinear system, nonlinear system analysis, Introduction to sensors and sensing systems, Sensor terminology: Transducers, input, output, active and passive, Accuracy, precision, resolution, sensitivity (responsively), linearity, range, relative error, absolute error. Primary and secondary sensors. Design of integrated solid state sensors. Date acquisition circuits. Micro-actuators and integrated Microsystems.

EE-6109 Robotics and its Application of Industrial Electronics

Evolution of Robots and Introductory aspects of Robotics, Homogeneous Transforms, Robot arm kinematics, Robot configurations, Inverse Kinematics, Robot Dynamics, Robot Autonomy, Mobility, Manipulation, Sensing, Control and Navigation, Work-space considerations and planning, obstacle Avoidance, Robot Algorithms and Program Design, Advanced Robot- ics Example and case studies.

EE-6110 Selected Topics in Industrial Electronics

Topics to be selected from emerging technologies and trends in the field of Electronic Engineering. Contents vary from year-to-year according to student and instructor in-charge interest.

EE-6113 Fuzzy Logic and Intelligent Electronic Control Systems

Introduction to Fuzzy logic, Fuzzy logic sets and systems, Fuzzy modeling, control and decision making, Supervised learning and neural networks, back propagation, radial-base functions, associative memory and pattern recognition, self-organization systems, neuro fuzzy logic controllers, neuro-fuzzy logic, hybrid controllers, applications, implementation.

EE-6114 Solid State Drives

Variable speed drive systems, Separately excited and series DC motor single phase drives, power factor improvement. Three phase drives, Semi Converter, Full Converter, Series connected and dual converter drives. Reversible drives. DC Chopper drives. Dynamic and regenerative braking. Closed loop control, Phase locked Loop control and Microprocessor control. Review of three phase induction motor speed control, Speed control by Slip-Energy Recovery schemes, Induction motor with voltage source inverters, Induction motor with current source inverters, Synchronous motor drives. Stepper motor drives. Cyclo-converter controlled AC drives. Brushless synchronous machines.

EE-6115 FPGA Based Systems

This course introduces fundamentals and circuit architectures of field programmable gate arrays (FPGAs), design tools supporting FPGA-based system designs, and their applications in reconfigurable computing. Students will gain hands-on experience of designing system with FPGAs, and learn the basics of design tools targeted for FPGA based designs. The applications of FPGAs in various custom computing environments will also be examined.

EE-7116 Digital Image Processing and its applications

Image sampling and quantization color, point operations, segmentation, morphological image processing, linear image filtering and correlation, image transforms, eigen images, multi-resolution image processing, noise reduction and restoration, feature extraction and recognition tasks, image registration. Emphasis is on the general principles of image processing. Students learn to apply material by implementing and investigating image processing algorithms in Matlab.

EE-7101 Research Methodology

Research Methodology is a hands-on course designed to impart education in the foundational methods and techniques of academic re- search in Electronic Engineering. Research scholars would examine and be practically exposed to the main components of a research framework i.e., problem definition, research design, data collection, ethical issues in research, report writing, and presentation. Once equipped with this knowledge, participants would be well-placed to conduct disciplined research under supervision in an area of their choosing. In addition to their application in an academic setting, many of the methodologies discussed in this course would be similar to those deployed in professional research environments.

EE-7112 Design of Industrial Control Systems

Analog and digital control system design. Analog controller design methods: lead and lag compensators, pole placement, model matching, two-parameter configuration, plant input/output feedback configuration. Introduction to state-space control system. State estimator and state feedback. Introduction to digital control system. Z-transform. Difference equations. Stability in the Z-domain. Digital implementation of analog controllers. Equivalent digital plant method. Alias signals. Selection of sampling time. PID controller. Project on specific topic or applications.

EE-7103 Mechatronics

Introduction to mechatronics; basic elements of mechatronic systems. Measurement systems: including principles of measurement systems; sensors and transducers; signal conditioning processes and circuits; filters and data acquisition. Actuation systems: mechanical actuation systems and electrical actuation systems. Controllers: control modes; PID controller; performance measures; introduction to digital controllers and robust control. Modeling and analysis of mechatronic systems; performance measures; frequency response; transient response analysis; stability analysis.

EE-7104 Dynamics and Controls of Nonholonomic Systems

Kinematics of nonholonomic systems; dynamics of nonholonomic systems. Euler-Lagrange equations; equations of motion of nonholonomic systems with Lagrangian multipliers; the reaction of ideal nonholonomic constraints; nonholonomic Caplygin systems; Bifurcation and stability analysis of the nonholonomic systems. Analysis and design of nonlinear control of nonholonomic systems, including kinematic control and dynamic control as well as force control. Controller designs with uncertain nonholonomic systems. Application examples including control of wheeled mobile robots and walking robots. A project.

EE-7105 Embedded System Modeling

Fundamental issues and state-of-the-art methods, tools and techniques for system-level design of heterogeneous multi-core embedded systems. Modeling at different levels, from abstract specification down to implementation across hardware-software boundaries. Embedded system specification using system-level design languages, SystemC and SpecC. Application modelling and analysis. Embedded multi-core platforms. Transaction-level platform modelling. Processor and RTOS modeling. Communication architecture modelling.

EE-7106 Advance Engineering Mathematics

A Brief Review, Numerical Solutions of Equations and Interpolation, Ordinary differential equations, The Laplace transformation, Fourier Methods, Linear Algebra, Systems of Ordinary Differential Equations, Partial Differentiation, Partial differential equations, Numerical Solutions of Partial Differential Equations, Integral Functions.

EE-7107 Linear System Theory

Review of linear algebra, state space representations. State transition matrix, linear time varying systems. Controllability, observability, stability, stabilizable, minimal realizations. Synthesis of linear controllers, pole placement, state feedback, observer design.

EE-7108 Adaptive Systems

Introduction: scope and objectives of the course, overview of issues in adaptive filtering, survey of a few applications. Random processes and signal modelling: discrete-time random processes, correlation and power spectrum, models: linear processes, harmonic processes, AR, MA, ARMA processes. Wiener filters and linear prediction: optimal linear filtering, forward and backward prediction, Levinson-Durbin algorithm. LMS adaptive filtering: method of steepest descent, LMS algorithm, stability and performance analysis. Method of least squares: least-squares solution, properties, singular value decomposition and pseudo-inverse, recursive least-squares method.

EE-7109 Advance Digital Signal Processing

Digital processing of continuous-time signals, Sampling and sampling theorem, Quantization, A/D and D/A conversion, DFT and FFT, Windowing, FFT structure, Digital filters, FIR-filters: Structures, linear phase filters, least-squares frequency domain design, IIR-filters: Structures, classical analog lowpass filter, approximations, conversion to digital transfer functions, Multirate digital signal processing.

EE-7110 Stochastic Processes

Probability and random variables, characteristic functions, transformation of random variables, sequences of random variables, linear mean squared estimation, stationary estimation, stationary random process, correlation functions power spectrum output of linear systems with stochastic input, Gaussian process. Markov chains, state classification, kolmogorov equations, applications to Probabilistic finite state machines, Birth death process, applications to queuing theory, buffer problems and the design of communication nets.

EE-7102 Simulation, Modelling and Optimization

In this course the students will study the constituents of the simulation and modelling methods of the physical systems using mathematical formulations. During the course, mathematical

modeling will

be described as a research and development tool. Recent engineering and development software uses a number of modelling techniques. Once the models are developed, the validation of the developed design is highly needed. With the techniques, student can use them to predict the behavior of the real world engineering system designs. The course will cover Modeling & simulation development process, Numerical and mathematical modelling, Introduction to MATLAB simulation tools, Managing Simulation Development, Classical Optimization Theory, Design of Experiments – Analysis of Variance (ANOVA), Response Surface Methods (RSM) and Verification and validation in systems engineering

EE-8103 Computer Vision & Pattern Recognition

Classification theory in terms of Bayesian costs, decision functions and the geometry of decision regions for continuous and discrete random variables, classification error probabilities and bounds, Maximum-Likelihood and Bayesian parameter estimation, Non parametric recognition, Parzen window operation, K-nearest neighbor classifier, decision trees, Algorithm independent machine learning, re sampling for estimating statistics and accuracy, mixture densities and identifiability, K-means clustering, unsupervised Bayesian learning, decision-directed approximation, hierarchical clustering, mini- mum spanning trees, Applications to computer vision problems of estimation and recognition.

EE-8104 Advanced Adaptive Control Systems

Overview of Adaptive Control Systems, advanced tools for stability of non-autonomous nonlinear systems, Stability of prototypical adaptive control systems, Adaptive observers for linear systems, Model reference control, Model reference adaptive control, Adaptive controllers for nonlinear systems, Robust redesign of adaptive control systems, Robustness of adaptive systems, Dead-zone and projection-based techniques, system identification of adaptive control systems, Model Free Adaptive Control.

EE-8105 Non-Linear Control Systems

Linear, non-Linear system theory, classification of control systems, linear system and its properties, LTI systems, modeling of systems, norms, inner-product, norm of linear operator, linear operators, rank, null-space, orthogonal complement, Eigen vector, controllability & observability of system, controllable canonical form, observable canonical form, Jordan canonical form, Jacobian linearization and gain scheduling, introduction to feedback linearization and extensions of optimal control techniques, state feedback estimator, techniques for the stability analysis of nonlinear and time-varying systems, internal stability of feedback systems, Lyapunov and MIT stability theorems.

EE-8106 Special Topics in Electronic Engineering – I

Topics will be chosen based on latest electronic engineering topics for research.

EE-8107 Special Topics in Electronic Engineering – II

Topics will be chosen based on latest electronic engineering topics for research.

Mathematics Courses

MS-6001 Mathematical Methods

Set theory, Relations on set, Functions, Samples & Selections, Mathematical Induction, Countability of sets, Discrete Sets, Continum, Elementary Algorithms, Elementary Recursion, Theory of Monoides & Groups, Complex numbers and their representation. Graphs as data structures, graphs and their special instances as trees. Finite State Machine, Infinite Machines, Turing machines & Non-deterministic Machines (NFA). Real analysis and, Elementary Measure Theory, limit points, some examples of sets that have discrete nature and have special distance / difference concepts.

MS-6101 REAL ANALYSIS

Review of real number system: Sequences, subsequences and series. Cauchy sequences. Completeness, convergence of series. Absolute and conditional convergence of series. Uniform convergence, difference between pointwise and uniform convergence of sequences and series of functions, continuity, differentiability, properties of continuous functions, types of discontinuities. Functions of several variables: Limit, continuity, differentiability of functions of severable variables. Taylor's theorem of functions of several variables, maxima and minima of functions of two and three variables. Method of La- grange multipliers. Implicit functions, Jacobians, functional dependence. The Riemann-Stieltjes (R-S) integral: Properties of R-S integra- ble functions of bounded variation. Mean value theorems. Conver- gence of improper integrals, Weierstrass M-test, theorem of improper integrals. Multiple integrals. Line and surface integrals.Theorems of Gauss, Stokes and Green. Differentiation under the integral sign.

MS-6105 COMPLEX ANALYSIS

Definitions, properties of complex numbers, polar form, De-Moivre's theorem and its applications, exponentials, limit, continuity, differentiability, ana1aytical functions Cauchy-Riemann equations,. Cauchy's theorem and integral formulae, power series, Taylor's series, Laurant's series, zeros and poles, classification of singularities, residues and Cauchy's residue theorem and its applications, argument principle, theorems of Rouche and Gauss-Lucas, contour integration, analytic continuation, Mobius transformation, Schwarz-Christoffel transformation, iterated functions system, fractals, algorithms to generate Sierpinski Gasket.

MS-6201 ABSTRACT ALGEBRA

Groups and subgroups. Generators and relations. Cyclic groups. Co-sets and Lagrange's theorem. Normalizers and centralizers. Centre of a group. Subgroups. Conjugacy classes of groups. Normal subgroups and simple groups. Factor groups. Commutators. Permutation groups and Cayley's theorem. Isomorphism theorems and automorphisms. Introduction to rings. Types of rings. Integral domains. Fields and their characteristics.

MS-6205 LINEAR ALGEBRA

Review of elementary concepts of vector spaces. Linear dependence and independence of vectors. Vector spaces and subspaces. Quotient spaces. Direct sum of spaces. Linear transformations. Rank and

nullity of linear transformations. Algebra of linear transformations and representation of linear transformations as matrices. Change of bases. Linear functionals. Dual spaces and annihilators. Eigenvectors, eigenvalues and Cayley-Hamilton theorem. Diagonalization of matrices. Inner product spaces. Bilinear, quadratic and Hermitian forms

MS-6301 GENERAL TOPOLOGY

Metric spaces, open sets, closed sets, convergence and continuity in metric spaces, topological spaces, bases and subbases, product topology, subspace topology, closed sets and limit points, closure, interior and boundary, Hausdorff spaces, continuous functions, homeomorphisms, metric topology. Connectedness, path connectedness, component and local connectedness, compact spaces, compact sub- spaces of the real line, limit point compactness, local compactness, first countable and second countable spaces, regular and normal spaces.

MS-6401 ORDINARY DIFFERENTIAL EQUATIONS

Review of ordinary differential equations with constant and variable coefficients, ordinary points, regular and irregular singular points and series solutions of differential equations. Frobenius method: The Bessel, Legendre, Hermite, Chebychev, hypergeometric equations and their solutions, orthogonal polynomials Sturm-Liouville systems. Adjoint differential equations. Linear systems of. differential equations, Cauchy's problems for linear second order equations in independent variables. Cauchy- Kowalewski theorem. Characteristic sur- faces. Adjoint operations, bicharacteristics. Spherical and cylinderical waves. Heat equation, wave equation, Laplace equation, maxi- mum-minimum principle. Integral transforms.

MS-6099 MS THESIS

The thesis is a report of theoretical or laboratory/practical work, suitable for publication. For the MS degree a Thesis is required. The Department will appoint an MS Thesis Supervisor for this purpose. The student will choose a suitable topic with the approval of his Supervisor who will guide, and monitor his/her progress and suggest reading material. A student will only graduate after the final acceptance of his/her thesis report.

MS-6110 MEASURE THEORY - I

Algebra of sets: The axiom of choice and infinite direct products, countable sets, relations and equivalences, partial ordering and the maximal principle, well-ordering and countable ordinals. The real number system : Axioms of real numbers, the natural and rational numbers as subsets of R, the extended real numbers, sequences of real numbers, open and closed sets of real numbers, continuous functions, Borel sets. Lebesgue measure: Introduction, outer measure, measurable sets and Lebesgue measure, A non measurable set, measurable functions, Little wood's three principles .Lebesgue integrals: The Riemann integral, the Lebesgue integral of a bounded function over a set of finite measure, the integral of a nonnegative function, the general Lebesgue integral, convergence in measure. Differentiation and Integration: Differentiation of monotone functions, functions of bounded variation, differentiation of an integral, absolute continuity, convex functions. The Classical Banach Spaces: The Lp spaces, Minkowski and Holder inequalities, convergence and completeness, approximation in L p, bounded linear functional on L p spaces.

MS-6115 FUNCTIONAL ANALYSIS – I

Banch spaces: Definition and examples of normed spaces, Banach spaces, characterization of Banach spaces, quotient spaces. Bounded linear transformations, functionals and their examples, various characterizations of bounded (continuous) linear operators, the space of all bounded linear operators. The open mapping and closed graph theorems. The dual (conjugate) spaces, reflexive spaces, Hahn-Banach theorem. Some important consequences of the Hahn-Banach theorem .Inner product spaces and their examples.The Cauchy-Schwarz inequalitity. Hilbert spaces. Adjoint, self-adjoint, normal and unitary operators (simple properties).

MS-6120 SUMMABILITY THEORY - I

General theory, regular transformations. Toeplitz theorems. Special methods of summability , Borel and Abel type methods of summability. Norülund means, Cesaro and Holder means. Summability of products of series, summability factors, summability of integrals, Hausdorff methods.

MS-6215 RING THEORY-I

Rings, subrings, characteristics of a ring, Boolean ring, direct products and direct sums of rings, ideals and homomorphisms, factor rings, sums and direct sums of ideals, maximal and prime ideals, nilpotent and nil ideals, modules and vector spaces, R-homomorphisms and quotient modules, simple and completely reducible modules.

MS-6501 INTRODUCTION TO CONTINUUM MECHANICS

Introduction to tensors. Stress tensor. Equilibrium equations. Mohr's circle for plane stress. Deformation, Strain tensor. Rate of deformation tensor. Equations of motion. Dynamic similarity. Exact solutions. Laminar boundary layer over a float plat. Vorticity circulation & irrational flow. Torsion of cylindricalbars. Plane elastic waves.

MS-6601 MATHEMATICAL STATISTICS

Introduction to probability, basic classical theorems, modes of probablistic convergence, random variable and its distribution, moment generating functions, characteristic functions, probability distribution of functions of random samples, theory of point and interval estimation, hypothesis testing, elementary decision theory.

MS-7110 MEASURE THEORY- II

Measure and integration: Measure spaces, measurable functions, integration, general convergence theorems, signed measures, the Ra- don-Nikodym theorem, the L p spaces. Measure and outer measure and measurability, the extension theorem, the Lebesgue-Stieltjes integral, product measure, extension by sets of measure zero, Caratheodory outer measure. Hausdorff measure. Measure and Topology: Baire sets and Borel sets, the regularity of Baire and Borel measures, the construction of Borel measures, positive linear functionals and Borel measures, bounded linear functionals on C(X).The Daniell inte- gral.

MS-7115 FUNCTIONAL ANALYSIS – II

Hahn-Banach theorem, Principle of uniform boundedness, open mapping theorem, closed graph theorem. Weak topologies and Ba-

nach-Alaoglu theorem, extreme points and the Klein-Milman theorem. The dual and bidual spaces, reflexive spaces, compact operators, spectrum of an operator, eigenvalues and eigenvectors, elementary spectral theory.

MS-7120 SUMMABILITY THEORY - II

Euler & Borel Methods: Generalization of some methods of summability, strong and absolute summability, Tauberian theorems. Wiener theory, special topics.

MS-7125 FOURIER ANALYSIS

Fourier series: Norm and pointwise convergence, approximate identities, Plancherel theorem, conjugation, maximal functions. Classical Hardy spaces, F. and M. Riesz theorems, interpolation of linear oper- ators. Fourier & Fourier Stieltjes transforms, tempered distributions, Paley-Wiener theorems. Wiener- Tauberian theorems & applications

MS-7215 RING THEORY-II

Free modules, Noetherian and Artinian rings and modules, composition series, projective modules, split exact sequences, the group of homomorphism, important homological properties, injective modules, characterization of injective modules, divisible abelian groups and their relationship with injective modules.

MS-7220 THEORY OF SEMIGROUPS

Introductory ideas, basic definitions, cyclic semi groups, ordered sets, semilattices and lattices, binary relations, equivalences, congruences, free semigroups, Green's equivalences, L, R, H, I and D, regular semigroups, 0-simple semigroups, simple and 0-simple semigroups, Rees's theorem, primitive independents, completely 0-simple semigroups, finite congruence-free semigroups, union of groups, bands, free bands, varieties of bands, inverse semigroups.

MS-7225 THEORY OF SEMIRINGS

Hemirings and semirings, definitions and examples, building new semirings from old. Complemented elements in semirings. Ideals in semirings. Prime and semiprime ideals in semirings. Factor semirings. Morphisms of semirings. Regular semirings. Semimodules, fac tor semimodules. Free, projective and injective semimodules.

MS-7230 FUZZY SET THEORY

Introduction, classical logic, classical set theory. Fuzzy sets: Basic concepts and properties, further properties, classical relations, fuzzy relations, fuzzy arithmetics, fuzzy logic, applications.

MS-7301 ALGEBRAIC TOPOLOGY

Homotopy of paths, the fundamental group. Covering spaces. Simplicial complexes and simplicial maps, homology groups, barycentric subdivision, the simplicial approximation theorem. Singular homol- ogy groups, The exact homology sequences, the Eilenberg-Steenrod axioms, Mayer-Vietoris sequence.

MS-7401 PARTIAL DIFFERENTIAL EQUATIONS

Cauchy's problems for linear second order equations in - independent variables. Cauchy- Kowalewski theorem. Characteristic surfaces. Adjoint operations, bicharacteristics. Spherical and cylinderical

waves. Heat equation, Wave equation, Laplace equation, maximum-minimum principle, integral transforms.

MS-7405 MATHEMATICAL TECHNIQUES FOR SCIENTISTS AND ENGINEERS

Green's function, method with applications to wave-propagation. Perturbation method, regular and singular perturbation techniques with applications. Variational methods. A survey of transform techniques, Wiener-Hopf technique with applications to diffraction problems

MS-7410 CALCULUS OF VARIATION AND INTEGRAL EQUATIONS

Euler's equation and its generalization: Variational problems with moving boundaries, Rayleigh-Ritz method. Classification of integral equations, Neumann's iterative method for Fredholm's equation of the second kind, Volterra type integral equations, integral equations of the first kind.

MS-7415 OPTIMIZATION

Optimization Problem: various examples, characterization of optimality and constrained optimal problems. Convex sets and convex functions and their properties, non-linear programming theory. Kuhn-Tucker conditions, Lagrange's theory, duality theory, search techniques-one variable and several variables, Pontyagin's maxi- mum principle and its applications, dynamic programming and its ap- plications.

MS-7420 INTEGRAL EQUATIONS

Volterra and Fredholm integral equations, resolvent kernels. Operator equations, Fredholm theory, Hilbert-Schmidt theory, nonlinear integral equations, singular integral equations

MS-7425 NUMERICAL SOLUTIONS OF ORDINARY DIFFERENTIAL EQUATIONS

Introduction. Runge-Kutta, methods, derivation, error bounds and error estimates. Weak stability theory for Runge-Kutta methods. Order and convergence of the general explicit one-step methods. Linear multi-step methods -derivation, order consistency, zero-stability and convergence. Weak stability theory for general linear multi-step methods. Predictor-corrector methods. Stiff systems.

MS-7430 NUMERICAL SOLUTIONS OF PARTIAL DIFFERENTIAL EQUATIONS

Basic linear algebra, vector and matrix norms and related theorems. Parabolic equations in one and two space dimensions - explicit and implicit formulae. Consistency, stability and convergence. Iterative methods for linear systems, split operator methods. Multilevel difference schemes. Nonlinear equations. Elliptic Equations: Dirichlet, Neumann and mixed problems. Direct factorization methods and successive over relaxation (S.O.R.). ADI and conjugate gradient methods. Hyperbolic equations. First order hyperbolic systems in one and two space dimensions-stability and convergence. Second or- der equations in one and two space dimensions. The Galerkin method and applications.

MS-7435 BIO-MATHEMATICS

Bio fluid dynamics; Blood flow & arterial diseases; Transport in intestines & lungs; Diffusion processes in human system; Mathematical study of nonlinear Volterra equations, Stochastic & deterministic models in population dynamics and epidemics.

MS-7501 FLUID MECHANICS

Introduction to fluid dynamics. Steady and turbulent flow. Conservation of mass in fluid flow, viscosity. Laminar and turbulent flow of ideal and viscous liquid. Euler's and Bernoulllis equation. Calculation of pressure variation in accelerating fluid surface resistance in laminar and turbulent flow. Evaluating head loss in pipes and conduits & solving engineering problem fluid flow. Calculating left and drag on morning liquid, Poisse formula. Calculating hydraulie pipe flow problem using Moodys diagram. Computational fluid dynamics Introduction to computational fluid dynamics. Fluid dynamics governing equation, Numerical Methods, Principle of CFD.

MS-7510 BASICS OF THE THEORY OF FLUIDS

Euler's equation of motion, viscosity, Naiver-Stokes equation and exact solutions, dynamical similarity and Reynold's number, turbulent flow, boundary layer concept and governing equations, Reynold's equations of turbulent motion. Magneto hydrodynamics, MHD equation, fluid drifts, stability and equilibrium problems

MS-7515 THEORY OF STABILITY

Stability of fluid flows, Bernard convection, Poisseuille flow. Rotatory cousette flow. Rayleigh-Taylor and Kelvin-Helmholtz problems. Nonlinear stability limits. Supercritical and subcritical regimes.

MS-7520 COMPUTATIONAL FLUID DYNAMICS

Conservation laws, weak solutions & shocks, monotone difference schemes. Total variation diminishing schemes, Godunov-type schemes, essentially non oscillatory methods. Flux limiters

MS-7525 AERODYNAMICS

Introduction to aerodynamics, review of the fluid kinematics and conversation laws of vorticity theorem. Two dimensional potential flow. Aerofoil theory, finite wing oblique shocks, subsonic, transonic and supersonic airfoil theory, laminar and turbulent boundary layers, lift reduction, down force generation and drag reduction. Wind tunnel listing technique. Computational aerodynamics. Solving problems by the use of commercial packages in aerodynamics.

MS-7530 BIO-MECHANICS

Introduction to bio-mechanics, Circulatory system, pressure & flow in arterial system, elastic & non-Newtonian effects on blood flow. Arterial diseases, dialysis, artificial kidneys. Human joints & their mechanism, human joint lubrication; mucus transport in lungs.

MS-7601 ELEMENTARY DECISION THEORY

Utility and loss functions, the prior information, basic principles of making decisions under uncertainty, Bayes and minimax decision rules, prior and posterior analysis, applications to classical statistical inference procedures.

MS-7605 OPERATIONS RESEARCH

Different techniques used in operations research and their applications, formulation and solution of linear programming problems, queuing systems, rehabilitee analysis, probabilistic risk analysis.

MS-7610 APPROXIMATION THEORY

Best approximation in normed spaces. Tchebycheff systems. Tchebycheff- Weierstrass - Jackson - Bernstein - Zygmund-Nikolaev etc. theorems. Fourier series, splines, convolutions, linear positive, variation diminishing. Simultaneous etc. approximations. Direct-inverse-saturation theorems, applications.

MS-7615 STOCHASTIC PROCESSES

Definition and classification of general stochastic processes. Markov chains with discrete state space, Poisson process, birth and death processes. Renewal Process: renewal equation, mean renewal time, stopping time. Markov process with continuous state space: Introduction to Brownian motion.

MS-7620 MATHEMATICAL MODELING

Elementary mathematical models. Role of mathematics in problem solving. Concepts of mathematical modeling. System approach formulation. Analysis of models. Sensitivity analysis & parameter estimation. Design of experiment, validation. Simulation approach. Pitfalls in modeling. Illustrations.

MS-7701 DATA STRUCTURE

Introduction to data structures, Mathematical background, how to create and analyze programs. Arrays, Records and Pointers: Introduction, linear arrays, multidimensional arrays, records, pointers, representation of arrays, Sparse matrices. Stacks and Queues: Introduction, representation of stacks, evaluation of expression, recursion, representation of queues, circular queues. Linked Lists: Singly linked lists, linked stacks and queues, circular linked lists, application of linked lists, polynomial addition, sparse matrices, Generalized lists. Trees, basic terminology, binary tree representation, binary tree traversal. Application of trees. Hash Tables: Direct address tables, Hash tables. Hash functions. Overflow handling. Red-Black Trees: Properties of Red- Black tree, rotations, insertion, deletion. Advanced data Structures: B-Trees, heaps, data structure for disjoint sets. Design and Analysis Techniques: Dynamic programming, Greedy algorithms, examples. Graphs: Representation of graphs, Traversals: Depth first search, breadth first search, minimum spanning tree,shortest paths.

MS-7705 MATHEMATICAL CODING THEORY

Polynomial rings over fields. Extension of fields, computation in GF(q), root fields of polynomial.Vector space over finite fields, binary group codes, hamming codes, polynomial codes, linear block codes, the structure of cyclic codes. Quadratic residue codes, Reed-Muelier codes, simplex codes.

MS-7710 GRAPH THEORY

Basic definitions. Blocks, Ramsey numbers. Degree sequences. Connectivity. Eulerian and Hamiltonian graphs. Planar graphs and 5-colour theorem. Chromatic numbers. Enumeration, Max-Flow Min-Cut theorem. Groups and graphs. Matrices and graphs. Matchings and Hall's Marriage theorem. Eigenvalues of graphs.

MS-7715 THEORY OF COMPUTATION

Some fundamental proof techniques. Finite Automata: Finite automata and regular languages, languages that are and are not regular, algorithm aspects of finite automata. Context-free grammars: Push- down automata, languages that are and are not context-free, algorithms for context-free grammars. Basic turing machine model and turing computability: Variants of turing machines.

MS-7720 NUMERICAL ANALYSIS

Differentiation and integration in multi-dimensions , ordinary differential equations : predictor methods, modified Euler's method, truncation error and stability, Taylor series method , Runge-Kutta methods, differential equations of higher order, systems of differential equations, shooting methods, boundary value problems. Partial differential equations: Elliptic, hyperbolic and parabolic equations, explicit and implicit finite difference methods, stability, convergence and consistency analysis, the method of characteristic.

MS-7801 DIFFERENTIAL GEOMETRY

Theory of Space Curves: The Serret-Frenet formulas. Gauss theory of surfaces, first and second fundamental forms. Examples, Weingarten map. Principal curvatures, Gaussian curvature, examples. Computation of the curvature in standard spaces, sphere, torus, surfaces of revolution etc. Levi-Civita connection, uniqueness, Gauss theorem, Egregium, Hubert's theorem on the positivity of curvature at a point on a compact surface in R3, geodesics, equations of geodesics, examples, Jacobi fields, conjugate points etc., Riemannian area element on a surface, Gauss-Bonnet theorem. Differential manifolds, differentiable structure, submanifolds, immersions, embeddings. Metric tensor, Riemannian connections and curvature.

MS-7901 SPECIAL TOPICS -II

Topics will be chosen based on industry trends and requirements.

Telecommunication Engineering Courses

TE-6121 Communication Systems

Overview of system types, analog and digital communications, power-bandwidth tradeoffs, signal-to-noise ratio, channel capacity concepts. Classification and representation of signal, fourier representation, energy and power spectral density, linearity, types of distortion. Amplitude modulation (AM), carriers and modulation, types of amplitude modulation, AM receivers, Generation and detection of DSB-LC and DSB-SC signals. Transmission bandwidth. Power and ca-

reer in signal. Angle modulation (FM and PM), Instantaneous frequency, approximate analysis of angle modulation (bandwidth, spectral content), FM-PM receivers. Equations for FM and PM. Single tone narrow band and wide band FM: Bessel functions. Carson's rule. Power in career and signal, modulators: Direct and indirect. Dmodu - lators: discriminators, delay (phase shift or Quadrature) detector. FM receiver. Pre-emphasis/de emphasis. Pulse and digital communications, sampling and pulse-code modulation (PCM), line coding, pulse shaping, error control, digital carrier systems. Multiplexing techniques; FDM, TDM. Sampling theorem, Nyquest Frequency. Sprectral density of signals. PCM encoder, regenerator, decoder, ISI and Nyquist filters. TDM and PCM frames. TI system. Binary signal formats and spectral densities. ASK, FSK, PSKI: Modulators, Demod- ulators. Multiple access techniques; FDMA, TDMA, CDMA, SDMA.

TE-6122 Data Networks

Fundamentals of network technology, OSI reference model, Introduction to cables and signals, Analysis of link layer protocols and their performance. Overview of Network architectures, Network protocols, Transport protocols, A Summary of upper layer protocols. Overview of the telephone network.

TE-6123 Information Theory and Coding

Introduction to information theory, Measurement of information, Encoding of Source output, Discrete sources, McMillan Theorem, Noisy channel and information transmission rate, Noiseless coding theorem, Continuous and discrete communication channels, Shanon's theorem of noisy channel, Error control coding, Error-detecting codes/Error correcting codes, continuous messages and continuous channel, Reproduction with a fidelity criterion, Basic theorem for a continuous channel.

TE-6124 Analysis Stochastic Processes

Introduction to probability theory, Axioms of probability, Conditional probability, Bayes rule, Binomial distribution, Poisson distribution. Random variable, Cumulative distribution, Probability Density function; Gamma density, Poisson density, Gaussian density and Rayleigh density. Function of one random variable, Two random variable and extension to n-random variables, Moment and conditional statistics, Random sums and conditional densities, Mean square estimation, least mean square estimation, Linear transformation of Gaussians, Stochastic convergence and central limit theorem, Stochastic processes and random waveforms, Ergodicity, Power Spectrum, System with Stochastic inputs, Gaussian Noise, Orthogonal function expansion of Stochastic processes.

TE-6125 Digital Signal Processing

Introduction and scope, Comparison between continuous time signals and discrete time signals, Digital representation of analog signals, Frequency domain and Z-transforms, Digital filter realization, IIR and FIR filter design techniques, Fast Fourier transform algorithms. Sources of error in digital systems, Analysis of noise in digital systems, Spectrum analysis, IC based signal processors.

TE- 6126 Wireless and Mobile Communication Systems

Fundamentals of wireless communication systems, including data networks, cellular telephone and personal communication systems.

Protocol, Architecture, Signaling and Performance issues of wireless communication systems. Multiple Access techniques for digital wireless communication systems. Wireless networking, Wireless system and standards; AMPS, GPS etc.

TE-6127 Management and Security Of Telecommunication Networks

Network Management in TCP/IP Environments, Network Management Station (NMS), Network Management Requirements, Network Management Protocols, Abstract Syntax Notation One (ASN.1), OID/MIB, CMIS/CMIP, SNMP (V1, V2, V3), Structure of Management Information (SMI), Remote Monitoring (RMON), SNMP Commands, Telecommunications Management Network (TMN), Network Management Tools and Systems, Principles of network security management; policies and technical issues, Benefits, Encryption, Authentication, Integrity, Protection, Speech Cryptography, Speech Scrambling Techniques.

TE- 6128 Broad Band Communication Systems

Overview of communication networks, Metropolitan and wide area networks, Frame relay, SMDA, ATM and SONET, Broadband ISDN architecture, Advances in broadband technologies based on fast switching and streamline protocols.

TE- 6129 Software Tools and Techniques In Telecommunication

For students who were not computer science or information science undergraduates. Builds upon the programming skills required for admission and presents concepts, algorithms, and methodologies related to data structures, file systems, and operating systems essential to other courses in the curriculum.

TE- 6130 Antennas and Applied EM

Fundamentals of antennas and EM wave propagation, analysis, characterization, synthesis and computer-aided design, and applications in communications. Antenna noise temperature, Radar polarimetry, Remote-sensing techniques and tomography applications Remote sensing, and radars. Radiation pattern, directivity, impedance, wire antennas, arrays, numerical methods for analysis, horn antennas, microstrip antennas, and reflector antennas.

TE- 6131 Optical Communication Systems

Review of optical signal propagation through Optical Fibers; Multimedia fibers, Graded-index fibers, single mode fibers, Dispersion shifted and dispersion flattened fibers. Mode spot size and propagation characteristics, Intensity modulation, direct detection systems, Coherent systems, unguided optical communication systems, Local area optical fiber networks.

TE- 6132 Digital Communication and Information Storage

Principles of digital communication, Architectures and Formats of digital transmission systems (especially the asynchronous and synchronous digital hierarchies), Signal-to-noise ratio, Link power budgets, Analog-to-digital conversion, Data compression, Digital modulation, and facility switching, Function and connection of computing devices for distributing, storing and sharing information locally and over a network.

TE- 6133 Satellite Communication

Overview of satellite communication, Selection of frequencies, Earth station and antenna structure for satellites, Digital modulation schemes for satellite communication, Multiplexing and multiple access techniques used in satellite communications, Satellite networks, Direct broadcasting satellite, Practical details and configuration of various satellite communication systems of the world.

TE 6134 Advanced Information Security

This course is an advance level course in Information security that deals with advance topics in Information Security to include theory and practice of cryptographic techniques used in communication security. The topics such as encryption (secret-key and public-key), message integrity, digital signatures, user authentication, key management, cryptographic hashing, Network security protocols (SSL, IP- sec), public-key infrastructure, etc will be covered to students who want to adopt Information Security as a specialization in their career.

TE- 7111 Lightwave Engineering

Review of basic principles of optics, Optical fiber, sources, Optical detectors, Optical couplers, Optical switches, Light transmission, Optical transmission systems. Semiconductor laser amplifiers and Optical fiber amplifiers, Integrated optics, Optical integrated circuits (OICs) and Optoelectronics integrated circuits (OEICs), Optical LANs.

TE- 7112 Advanced Communication Networks

Overview of interfaces that interconnect hardware and software components in a telecommunications environment necessary for the orderly operation of a network. Analysis and demonstration of eachof the interface standards and protocols. Functions and benefits of networks of communicating and information processing equipment. Underlying technologies and standards of such networks. Currently available products and future developments. Analysis and description of client-server based systems. Remote procedure calls and socket programming. Analysis of system-level issues (reliability, consistency, etc.)

TE- 7113 Advance Filter Design

Methods and techniques for digital signal processing. Review of sampling theorems, A/D and D/A converters. Demodulation by quadrature sampling. Z-transform methods, system functions, linear shift- invariant systems, difference equations. Signal flow graphs for digital networks, canonical forms. Design of digital filters, practical considerations, IIR and FIR filters. Digital Fourier transforms and FFT techniques.

TE- 7114 IP Telephony

Introduction of digital voice networks, Voice digitization, Digital transmission, Multiplexing and switching, Dialing and signaling, Integration of voice and data, Protocols for IP telephony: SIP, H.323, MGCP, including call flows, network components, security, routing, and advanced services, Transport of real-time traffic over IP (RTP and RTCP), bandwidth control and issues in network quality of service, such as traffic modeling, dimensioning and QoS mechanisms.

TE- 7115 TELETRAFFIC ENGINEERING AND NETWORK PLANNING

Teletraffic engineering overview, Quality of Service, Network performance optimization; Classification of teletraffic engineering systems

and traffic parameters, Traffic data collection techniques and statistics, Modeling of non-queuing and queuing systems, Modeling of sys- tem with mobile users, Fundamentals of network simulation and planning.

TE- 7190 SPECIAL TOPICS IN TELECOMMUNICATION-I

Topics will be selected from new emerging technologies and trends in the field of telecommunication.

TE- 7191 SPECIAL TOPICS IN TELECOMMUNICATION-II

Topics will be selected from new emerging technologies and trends in the field of telecommunication.

TE-7199 MS THESIS

The student is required to choose and conduct independent research and/or development work, theoretical or experimental, under the supervision and guidance of supervisor as per university rules

Policies

Semester Rules

Semester/Course Registration

- A student must register each semester (within the prescribed period) until the completion of degree requirements. Failure to register in two consecutive semesters without prior intimation and approval may result in cancellation of admission without notice.
- A student can register in maximum of 03 courses in a semester.

Course Add/Drop

- Course Add/Drop date shall be set around three weeks from the commencement of a semester and shall be announced at the beginning of the semester.
- A student can add/drop any course (due to any reason) before the Course Add/Drop date without any financial or academic penalty.
- A student is not required to pay course fee for a course dropped within the Course Add/Drop date. If fee is already paid, then it will be credited to another course of the same semester or next semester.
- Students dropping a course after Add/Drop date and two weeks before the Final Exam (whether attended classes or not) get 'W' grade and have to pay full course fee.
- If a student does not drop a course (whether attended classes or not) and does not appear in the Final Exam gets 'F' grade and pays full course fee.

Course Withdrawal

- A student can apply for withdrawal from any course two weeks before the final examination.
- Full fee is payable for any withdrawn course(s). The university does not refund full or partial fee under any circumstances.
- The transcript shows “W” grade for any withdrawn course. The GPA calculation does not include letter grade “W”.

Attendance Requirements:

- A student is required to attend at least 80% of the conducted classes to be eligible to appear in final examination of a course.
- The Vice Chancellor has the authority for 5% condonation in this attendance requirement.

- If a student's attendance in a course is short of the minimum requirement, the concerned teacher shall award "F" grade to the student in that course.

Course Examination

- A total of 100 marks are assigned to a course for the purpose of examination and grading. The scheme of marking is as follows:
  - Sessional Evaluation: 50 marks
    - Quizzes, Assignments, Presentations, etc. (30 marks)
    - Mid-semester Examination (20 marks)
  - Final Examination: 50 marks
- To pass a course, a student must obtain a minimum of 50% marks in Sessional Evaluation and 50% marks in Final Examination.
- The duration of examination shall be as follows:
  - Mid-semester Examination: 1.5 hours
  - Final Examination: 2.5 hours

Grading Scheme

The grading scheme is as follows:

Grade	Grade Point	Percent Mark	Remarks
A	4.0	90 – 100	–
A-	3.7 – 3.9	85 – 89	–
B	3.4 – 3.6	78 – 84	–
B-	3.0 – 3.3	70 – 77	–
C	2.5 – 2.9	65 – 69	–
C-	2.0 – 2.4	60 – 64	–
D	1.0 – 1.9	50 – 59	–
F	0.0	00 – 49	Fail
P	–	50 – 100	Pass
N	–	00 – 49	Not Pass
I	–	–	Incomplete
S	–	–	Satisfactory
U	–	–	Unsatisfactory
W	–	–	Withdrawn

- Letter grades P, N, I, S, U and W are not used for GPA calculation.
- Letter grades P and N are awarded to non-credit courses e.g. pre-requisite courses or other such courses that do not contribute towards fulfilling the credit hours requirement for the award of a degree.
- Letter grades S and U are awarded for thesis examination.

Fee Structure

MS Fee Structure

Type	Amount	Frequency
Admission Fee	16,000	Once on Admission (Non-refundable)
Security Deposit	5,000	Once on Admission (Refundable)
Semester Registration Fee	2,500	Per Semester (Throughout Enrolment)
Tuition Fee	10,000	Per Course (3 Credit Hours)
Late Fee	200	Per Week#
Examination Fee	1,000	Per Course
MS Thesis*	20,000	-
MS Thesis Examination Fee	1,000	-

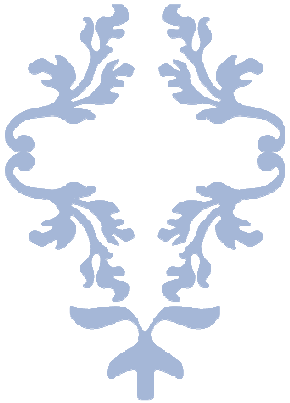
#If Tuition Fee is not paid by Course Add/Drop date, Late Fee is added per week until paid

**MS Thesis is of 6 Credit Hours that is equivalent to two courses*

PhD Fee Structure

Type	Amount	Frequency
Admission Fee	16,000	Once on Admission (Non-refundable)
Security Deposit	5,000	Once on Admission (Refundable)
Semester Registration Fee	2,500	Per Semester (Throughout Enrolment)
Tuition Fee	12,000	Per Course (3 Credit Hours)
Examination Fee:	1,000	Per Course
Written Comprehensive Exam Fee	5,000	Per Exam Attempt
Oral Comprehensive Exam Fee	5,000	Per Exam Attempt
Supervision Fee	20,000	Per Semester (During PhD Candidacy)
Late Fee	200	Per Week#
PhD Thesis Examination Fee	60,000	

#If Tuition Fee is not paid by Course Add/Drop date, Late Fee is added per week until paid



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