COURSES OF STUDY

Indian Institute of Technology Bhilai

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Terms Used

Undergraduate	A first-level degree program offered by the Institute.
Postgraduate	Degree programs offered by the Institute beyond the first-level.
Academic Program *aka* Program	The degree programs offered by the Institute, including undergraduate, postgraduate and research programs.
Academic Senate *aka* Senate	The Institute authority responsible for the promotion and maintenance of standards of research, instruction, education and examination. The senate carries out all decision making towards the academic and related activities.
Academic Year	An academic year starts in the month of July each calendar year and ends in the month of June of the next calendar year.
Semester	A division of an academic year (July-June), which comprises of three semesters – 2 regular semesters (Monsoon and Winter) and a Summer semester.
Monsoon Semester	A semester normally starting in the fourth week of July and continuing until the first week of December.
Winter Semester	A semester normally starting in the fourth week of December and continuing until the first week of May of the next calendar year.
Summer Semester	A semester normally starting in the second week of May and continuing until the second week of July.
DUGC	Department Undergraduate Committee.
DPGC	Department Postgraduate Committee.
Discipline	The specializations of program offerings by the Institute.
Grade	A letter system to indicate the performance of the students. Grades are awarded by the instructor in-charge of the course/thesis for the student. Each grade carries associated numeric points.
CGPA	Cumulative Grade Point Average. A weighted average of numeric points obtained in the courses cleared by a student.

SGPA	Semester Grade Point Average. A weighted average of numeric points obtained in the courses within a semester cleared by a student.
Fractals	Division of a semester which aligns with courses of various credits. Each regular semester is divided into six fractal segments.
Fractal Segment	A segment of semester roughly equivalent to one sixth of the semester. A course spans over one to six consecutive fractal segments.
Credit	The numeric value associated with courses to indicate the load for a course. Typically a course spanning over *k* fractal segments carries a credit of *k*.
Institute Core courses (IC)	A program may specify a set of courses that every student of that program must register for and must clear.
Professional core courses (PC)	A department may specify discipline-wise a set of courses for each programs that every student of specific discipline in the program must register for and must clear.
Departmental elective courses (DE)	A bouquet of courses offered by the department out of which the students must choose to register in order to fulfil the requirements of the discipline in the program and must clear. Department may also declare some specific courses offered by other departments a-priori as departmental elective courses. Departments shall specify the total number of credits that should be cleared with departmental elective courses.
Open elective courses (OE)	A bouquet of courses offered by various departments of the institute which the students must choose to register from his/her own department or from any other department and clear. A department will allocate zero or more slots for open electives in each program discipline-wise. Open electives are meant to widen the knowledge beyond the parent discipline and broaden the horizon by exposing the problems/areas in other disciplines. Departments shall specify the credits that should be cleared with open elective courses.
Creative Arts and Liberal Arts courses (CALA)	The Institute believes in a well-rounded development of its students. To that extent, Institute specifies program-wise credits to be earned by students amongst a bouquet of courses in Creative Arts and Liberal Arts.

Scope

The provisions of this *course of study* are applicable to all programs and disciplines. The academic senate may change any or all parts of this *course of study* at any time.

Introduction

IIT Bhilai offers a semester-oriented undergraduate, postgraduate and research programs with an objective of imparting best quality science and engineering education. Admissions to the academic programs are synchronized with an academic year, though in some cases, it may be synchronized to the start of a semester.

An academic year starts in the month of July each calendar year and ends in the month of June of the next calendar year. Each academic year is divided into three semesters – Monsoon, Winter and Summer semesters. The Monsoon and Winter semesters are two regular semesters while the Summer semester is a shorter semester.

IIT Bhilai is currently offering Bachelors of Technology (BTech), Master of Science (MSc), Masters of Technology (MTech) and Doctorate (PhD) programs in various departments/ disciplines. This document provides the curricula of all programs at IIT Bhilai along with the list of courses as on date.

Part A: Curriculum

Types of Courses

The course classification at IIT Bhilai is specific to the program and is categorized under five broad categories.

1. **Core courses (IC):** A set of courses that every student of a program at IIT Bhilai must register for and must clear.
2. **Professional core courses (PC):** For a program, the department may specify a set of courses discipline wise that every student of the specific discipline must register for and must clear.
3. **Departmental elective courses (DE):** A bouquet of courses declared by the department out of which students must register for and must clear program-wise specified minimum number of credits to fulfil the graduation requirements of the program.
4. **Open elective courses (OE):** A bouquet of courses offered by various departments of the institute, out of which the students must choose to register for and must clear a number of courses to meet the minimum specified OE credit requirements for a program. Open electives courses are meant to widen the knowledge beyond the parent discipline and broaden the horizon by exposing the problems/areas in other disciplines.
5. **Create Art and Liberal Art courses (CA/LA):** The Institute believes in a well-rounded development of its students. To that extent, Institute specifies a minimum number of program-wise credits to be earned by students amongst a bouquet of courses in Creative Arts and Liberal Arts.

Bachelor of Technology (BTech)

IIT Bhilai currently offers BTech program in five disciplines.

1. Computer Science and Engineering,
2. Data Science and Artificial Intelligence,
3. Electrical Engineering,
4. Mechanical Engineering, *and*
5. Mechatronics.

General structure of BTech program

BTech program at IIT Bhilai is a fully residential program with a nominal duration of 4 years.

Accordingly, the minimum credit requirements for students in various categories of courses to become eligible for the award of BTech Degree from IIT Bhilai is as follows.

S. No.	Category	Minimum Credits
1.	IC	60
2.	PC	60
3.	DE	60
4.	OE	30
5.	CA/LA	30
Total		**240**

The Discipline-wise curriculum of BTech program is mentioned in the following sections.

Discipline of Computer Science and Engineering

Semester I

Course Name	**Course Code**	**Credits**
Introduction to Programming	IC100	6
Digital Fabrication	IC101	6
Electromagnetism	IC102	2
Materials Chemistry I	IC103	2
Linear Algebra I	IC104	3
Probability and Statistics	IC105	4
Chemistry/Physics Lab	IC106/ IC107	3
Professional Communication Lab I – Sketching and Drawing	CA100	1
Essential Physical Activity	AA101	1
Creative and Liberal Arts courses	-	3
Total Credits (Excluding EPA)		**30**

In addition to the aforementioned courses, students have to spend sufficient number of hours in National Service Scheme (NSS) or National Sports Organization (NSO) activities as defined by the institute.

Semester II

Course Name	**Course Code**	**Credits**
Applied Digital Logic Design	IC150	6
Quantum Physics	IC151	2
Linear Algebra II	IC152	3
Calculus I	IC153	3
Physics/ Chemistry Lab	IC107/ IC106	3
Software Tools & Technologies Lab I	CS100	4
Discrete Structures I	CS101	4
Data Structures	CS102	4
Professional Communication Lab II - Presentation Skills	CA150	1
Total Credits		**30**

Semester III

Course Name	**Course Code**	**Credits**
Introduction to Astronomy and Astrophysics	IC200	4
Environmental Studies	IC201	2
Calculus II	IC202	3
Software Tools & Technologies Lab II	CS200	4
Discrete Structures II	CS201	2
Algorithms I	CS202	4
Theory of Computation I	CS203	4
Computer Organization & Architecture	CS204	4
Professional Communication Lab III – Technical Literature Structure	CA200	1
Creative and Liberal Arts courses	-	2
Total Credits		**30**

Semester IV

Course Name	**Course Code**	**Credits**
Materials Chemistry II	IC250	2
Basics of Bioinformatics	IC251	4
Operating Systems	CS250	4
Introduction to Language Processing	CS251	4
Algorithms II	CS252	4
Theory of Computation II	CS253	2
Database Management Systems	CS254	4
Professional Ethics	CA250	2
Creative and Liberal Arts courses	-	4
Total Credits		**30**

Semester V

Course Name	**Course Code**	**Credits**
Materials Chemistry III	IC300	2
Principles of Programming Languages	CS300	6
Computer Networks	CS301	6
Departmental Electives Courses	-	12
CALA Courses	-	4
Total Credits		**30**

Semester VI

Course Name	**Course Code**	**Credits**
Departmental Electives Courses	-	18
Open Electives Courses	-	6
CALA Courses	-	6
Total Credits		**30**

Semester VII

Course Name	**Course Code**	**Credits**
Departmental Electives Courses	-	12
Open Electives Courses	-	12
CALA Courses	-	6
Total Credits		**30**

Semester VIII

Course Name	**Course Code**	**Credits**
Departmental Electives Courses	-	18
Open Electives Courses	-	12
Total Credits		**30**

Discipline of Data Science and Artificial Intelligence

Semester I

Course Name	**Course Code**	**Credits**
Introduction to Programming	IC100	6
Digital Fabrication	IC101	6
Electromagnetism	IC102	2
Materials Chemistry I	IC103	2
Linear Algebra I	IC104	3
Probability and Statistics	IC105	4
Chemistry/Physics Lab	IC106/ IC107	3
Professional Communication Lab I – Sketching and Drawing	CA100	1
Essential Physical Activity	AA101	1
Creative and Liberal Arts courses	-	3
Total Credits (Excluding EPA)		**30**

In addition to the aforementioned courses, students have to spend sufficient number of hours in National Service Scheme (NSS) or National Sports Organization (NSO) activities as defined by the institute.

Semester II

Course Name	**Course Code**	**Credits**
Applied Digital Logic Design	IC150	6
Quantum Physics	IC151	2
Linear Algebra II	IC152	3
Calculus I	IC153	3
Physics/ Chemistry Lab	IC107/ IC106	3
Mathematical Foundations for Data Science	DS100	4
Discrete Structures I	CS101	4
Data Structures	CS102	4
Professional Communication Lab II - Presentation Skills	CA150	1
Total Credits		**30**

* Tentative. Subject to approval

Semester III

Course Name	**Course Code**	**Credits**
Introduction to Astronomy and Astrophysics	IC200	4
Environmental Studies	IC201	2
Calculus II	IC202	3
Operations Research	MA605	4
Algorithms I	CS202	4
Data Analytics and Visualization	DS250	6
Statistical Programming	DS201	4
Professional Communication Lab III – Technical Literature Structure	CA200	1
Creative and Liberal Arts courses	-	2
Total Credits		**30**

Semester IV

Course Name	Course Code	Credits
Materials Chemistry II	IC250	2
Basics of Bioinformatics	IC251	4
Architecture for Management of Large Datasets	DS200	6
Artificial Intelligence	DS251	6
Information Security	DS209	4
DSAI – Lab	DS252	2
Professional Ethics	CA250	2
Creative and Liberal Arts courses	-	4
Total Credits		**30**

* Tentative. Subject to approval

Semester V

Course Name	Course Code	Credits
Materials Chemistry III	IC300	2
Computer Networks	CS301	6
Machine Learning	DSXXX*	6
Departmental Electives Courses	-	12
CALA Courses	-	4
Total Credits		**30**

* Tentative. Subject to approval

Semester VI

Course Name	**Course Code**	**Credits**
Departmental Electives Courses	-	18
Open Electives Courses	-	6
CALA Courses	-	6
Total Credits		**30**

Semester VII

Course Name	**Course Code**	**Credits**
Departmental Electives Courses	-	12
Open Electives Courses	-	12
CALA Courses	-	6
Total Credits		**30**

Semester VIII

Course Name	**Course Code**	**Credits**
Departmental Electives Courses	-	18
Open Electives Courses	-	12
Total Credits		**30**

Discipline of Electrical Engineering

Semester I

Course Name	**Course Code**	**Credits**
Introduction to Programming	IC100	6
Digital Fabrication	IC101	6
Electromagnetism	IC102	2
Materials Chemistry I	IC103	2
Linear Algebra I	IC104	3
Probability and Statistics	IC105	4
Chemistry/Physics Lab	IC106/ IC107	3
Professional Communication Lab I – Sketching and Drawing	CA100	1
Essential Physical Activity	AA101	1
Creative and Liberal Arts courses	-	3
Total Credits (Excluding EPA)		**30**

In addition to the aforementioned courses, students have to spend sufficient number of hours in National Service Scheme (NSS) or National Sports Organization (NSO) activities as defined by the institute.

Semester II

Course Name	**Course Code**	**Credits**
Applied Digital Logic Design	IC150	6
Quantum Physics	IC151	2
Linear Algebra II	IC152	3
Calculus I	IC153	3
Physics/ Chemistry Lab	IC107/ IC106	3
Digital Signal Processing	EE101	4
Circuits and Systems	EE103	6
EE Independent Project	EE171	2
Professional Communication Lab II - Presentation Skills	CA150	1
Total Credits		**30**

Semester III

Course Name	**Course Code**	**Credits**
Introduction to Astronomy and Astrophysics	IC200	4
Environmental Studies	IC201	2
Calculus II	IC202	3
Electronic Devices	EE201	4
Control Systems - I	EE202	6
Embedded Systems	EE203	4
Engineering Electromagnetics	EE207	4
Professional Communication Lab III – Technical Literature Structure	CA200	1
Creative and Liberal Arts courses	-	2
Total Credits		**30**

Semester IV

Course Name	**Course Code**	**Credits**
Materials Chemistry II	IC250	2
Basics of Bioinformatics	IC251	4
Analog Circuits	EE204	6
Power Engineering - I	EE205	6
Electrical Machines	EE208	4
Electrical Engineering Lab - I	EE251	2
Professional Ethics	CA250	2
Creative and Liberal Arts courses	-	4
Total Credits		**30**

Semester V

Course Name	**Course Code**	**Credits**
Materials Chemistry III	IC300	2
Communication Systems	EE301	4
Electrical Engineering Lab – II	EE351	2
Departmental Elective Courses	-	18
CALA Courses	-	4
Total Credits		**30**

Semester VI

Course Name	**Course Code**	**Credits**
Electrical Engineering Lab - III	EE352	2
Electrical Engineering Lab - IV	EE353	2
Departmental Elective Courses	-	12
Open Elective Courses	-	6
Independent Project	EE371	2
CALA Courses	-	6
Total Credits		**30**

Semester VII

Course Name	**Course Code**	**Credits**
Departmental Elective Courses	-	12
Open Elective Courses	-	12
CALA Courses	-	6
Total Credits		**30**

Semester VIII

Course Name	**Course Code**	**Credits**
Departmental Elective Courses	-	18
Open Elective Courses	-	12
Total Credits		**30**

Discipline of Mechanical Engineering

Semester I

Course Name	**Course Code**	**Credits**
Introduction to Programming	IC100	6
Digital Fabrication	IC101	6
Electromagnetism	IC102	2
Materials Chemistry I	IC103	2
Linear Algebra I	IC104	3
Probability and Statistics	IC105	4
Chemistry/Physics Lab	IC106/ IC107	3
Professional Communication Lab I – Sketching and Drawing	CA100	1
Essential Physical Activity	AA101	1
Creative and Liberal Arts courses	-	3
Total Credits (Excluding EPA)		**30**

In addition to the aforementioned courses, students have to spend sufficient number of hours in National Service Scheme (NSS) or National Sports Organization (NSO) activities as defined by the institute.

Semester II

Course Name	**Course Code**	**Credits**
Applied Digital Logic Design	IC150	6
Quantum Physics	IC151	2
Linear Algebra II	IC152	3
Calculus I	IC153	3
Physics/ Chemistry Lab	IC107/ IC106	3
Engineering and Machine Drawing	ME102	3
Thermodynamics	ME111	6
Fundamentals of Metallurgy	ME151	3
Professional Communication Lab II - Presentation Skills	CA150	1
Total Credits		**30**

Semester III

Course Name	**Course Code**	**Credits**
Introduction to Astronomy and Astrophysics	IC200	4
Environmental Studies	IC201	2
Calculus – II	IC202	3
Solid Mechanics – I	ME231	6
Manufacturing Science – I	ME251	6
Fluid Mechanics	ME212	6
Professional Communication Lab III – Technical Literature Structure	CA200	1
Creative and Liberal Arts courses	-	2
Total Credits		**30**

Semester IV

Course Name	**Course Code**	**Credits**
Materials Chemistry II	IC250	2
Basics of Bioinformatics	IC251	4
Heat and Mass Transfer	ME213	6
Dynamics	ME232	6
Manufacturing Science II	ME352	6
Professional Ethics	CA250	2
Creative and Liberal Arts courses	-	4
Total Credits		**30**

Semester V

Course Name	**Course Code**	**Credits**
Materials Chemistry III	IC300	2
Theory of Machines and Mechanisms	ME333	6
Mechanical Engineering Lab I	ME371	3
Mechanical Engineering Lab II	ME372	3
Departmental Electives Courses	-	12
Creative and Liberal Arts Courses	-	4
Total Credits		**30**

Semester VI

Course Name	**Course Code**	**Credits**
Design of Machine Elements	ME334	6
Departmental Electives Courses	-	12
Open Electives Courses	-	6
Creative and Liberal Arts Courses	-	6
Total Credits		**30**

Semester VII

Course Name	**Course Code**	**Credits**
Departmental Electives Courses	-	12
Open Electives Courses	-	12
Creative and Liberal Arts Courses	-	6
Total Credits		**30**

Semester VIII

Course Name	**Course Code**	**Credits**
Departmental Electives Courses	-	18
Open Electives Courses	-	12
Total Credits		**30**

Discipline of Mechatronics

Semester I

Course Name	Course Code	Credits
Introduction to Programming	IC100	6
Digital Fabrication	IC101	6
Electromagnetism	IC102	2
Materials Chemistry I	IC103	2
Linear Algebra I	IC104	3
Probability and Statistics	IC105	4
Chemistry/Physics Lab	IC106/IC107	3
Professional Communication Lab I – Sketching and Drawing	CA100	1
Essential Physical Activity	AA101	1
Creative and Liberal Arts courses	-	3
Total Credits (Excluding EPA)		**30**

In addition to the aforementioned courses, students have to spend sufficient number of hours in National Service Scheme (NSS) or National Sports Organization (NSO) activities as defined by the institute.

Semester II

Course Name	Course Code	Credits
Applied Digital Logic Design	IC150	6
Quantum Physics	IC151	2
Linear Algebra II	IC152	3
Calculus I	IC153	3
Physics/Chemistry Lab	IC107/IC106	3
Circuits and Systems	EE103	6
Dynamics	ME232	6
Professional Communication Lab II – Presentation Skills	CA150	1
Total Credits		**30**

Semester III

Course Name	Course Code	Credits
Introduction to Astronomy and Astrophysics	IC200	4
Environmental Studies	IC201	2
Calculus – II	IC202	3
Theory of Machines and Mechanisms	ME333	6
Control System – I	EE202	6
Sensors and Instrumentation	MT***	4
Mechatronics Lab – I	MT***	2
Professional Communication Lab III – Technical Literature Structure	CA200	1
Creative and Liberal Arts courses	-	2
Total Credits		**30**

Semester IV

Course Name	**Course Code**	**Credits**
Materials Chemistry II	IC250	2
Basics of Bioinformatics	IC251	4
Embedded System for Mechanical Controls	MT***	6
Fundamental of Robotics	MT***	6
Hydraulics and Pneumatics Systems	MT***	6
Professional Ethics	CA250	2
Creative and Liberal Arts courses	-	4
Total Credits		**30**

Semester V

Course Name	**Course Code**	**Credits**
Materials Chemistry III	IC300	2
Solid Mechanics-I	ME231	6
Digital Control	MT***	2
Mechatronics Lab – II	MT***	2
Mechatronics Lab – III	MT***	2
Departmental Electives Courses	-	12
Creative and Liberal Arts courses	-	4
Total Credits		**30**

Semester VI

Course Name	**Course Code**	**Credits**
Introduction to Microfabrication	MT***	3
Design Project	MT***	3
Departmental Electives Courses	-	12
Open Electives Courses	-	6
Creative and Liberal Arts courses	-	6
Total Credits		**30**

Semester VII

Course Name	**Course Code**	**Credits**
Departmental Electives Courses	-	12
Open Electives Courses	-	12
Creative and Liberal Arts courses	-	6
Total Credits		**30**

Semester VIII

Course Name	**Course Code**	**Credits**
Departmental Electives Courses	-	18
Open Electives Courses	-	12
Total Credits		**30**

Bachelor of Technology with Honours (BTech (Honours))

General structure of BTech (Honours) program

Students completing two years of BTech program in IIT Bhilai can opt for conversion to BTech (Honours) subject to the conditions and procedures prescribed by the Senate. IIT Bhilai offers BTech (Honours) program in two different modes.

1. Through additional courses in a discipline (called as specialization) other than the one, student has registered for his BTech program.
2. Through thesis in the discipline, the student has registered for his BTech program.

The structure of BTech (Honours) program upto 4th Semester remains same as that of BTech program. From 5th Semester onwards, in addition to the courses mentioned in the BTech program structure, BTech (Honours) students have to register for additional six credits per semester towards discipline-specific courses/thesis based on the mode of their BTech (Honours) program.

BTech (Honours) through thesis

i. Students admitted to thesis-based BTech (Honours) must earn a minimum of 18 credits through thesis. Thesis credits are earned by registering for thesis course.

ii. Students would register for additional courses from 5th semester of their BTech program with the nominal load of 36 credits to fulfill the credit requirements of BTech (Honours) program.

iii. Students shall register for thesis credits from their 6th semester onwards. Students should register for thesis credits for a minimum of 2 semesters.

iv. Students can make use of the summer semester between the 5th and 6th semester for executing the research work by registering for thesis not exceeding 12 credits during the summer semester.

v. Thesis credits will be evaluated and graded in units of 6 credits (i.e.) there will be a grade associated with every 6 thesis credits (or part thereof) registered for.

vi. Students should do the research work towards a minimum thesis credit requirement of 18. The remaining credit requirements for BTech (Honours) should be earned by registering for courses within/across the department(s).

vii. Upon recommendation of the supervisor, the DUGC convener may permit the students to register for more than 18 thesis credits.

BTech (Honours) through Courses

The curriculum for course-based BTech (Honours) in various disciplines/departments are as follows.

Discipline of Computer Science and Engineering

Students in BTech (Honours) through courses in the specialization of Computer Science and Engineering will take the following courses as per the requirement of the program.

Course Name	Course Code	Credit	Compulsory/Optional
Data Structure	CS102	4	Compulsory
Discrete Structure – II	CS201	2	Compulsory
Algorithms – I	CS202	4	Compulsory
Computer Organization and Architecture	CS204	4	Compulsory
Theory of Computation – I	CS203	4	Optional
Operating Systems	CS250	4	Optional
Database Management Systems	CS254	4	Optional

The student must earn a minimum of 18 credits from the above-prescribed courses. Apart from this, students have to register for courses of their choice within the department (EECS) for 6 more credits.

Discipline of Data Science and Artificial Intelligence

Students in BTech (Honours) through courses in the specialization of Data Science and Artificial Intelligence will take the following courses as per the requirement of the program.

Course Name	Course Code	Credit	Compulsory/Optional
Data Analytics and Visualization	DS250	6	Compulsory
Artificial Intelligence	DS251	6	Compulsory
Foundations of Data Science	DS100	4	Optional
Architecture for Management of Large Datasets	DS200	6	Optional
Statistical Programming	DS201	4	Optional
DSAI Lab	DS252	2	Optional
Machine Learning	DS***	6	Optional

The student must earn a minimum of 18 credits from the above-prescribed courses. Apart from this, students have to register for courses of their choice within the department (EECS) for 6 more credits.

Discipline of Electrical Engineering

Students in BTech (Honours) through courses in the specialization of Electrical Engineering must earn a minimum of 18 credits by registering to any of the following courses of their choice:

Course Name	Course Code	Credit	Compulsory/Optional
Digital Signal Processing	EE101	4	Compulsory
Circuits and Systems	EE103	6	Compulsory
Control System-I	EE202	6	Optional
Power Engineering-I	EE205	6	Optional
Communication systems	EE301	4	Optional
Power Engineering-II	EE306	6	Optional

The student must earn a minimum of 18 credits from the above-prescribed courses. Apart from this, six more credits must be earned by registering further to any of the above stated courses or other courses within the department (EECS).

Discipline of Mechanical Engineering

Students in BTech (Honours) through courses in the specialization of Mechanical Engineering must earn 18 credits by registering to the following courses:

Course Name	Course Code	Credit	Compulsory/Optional
Solid Mechanics – I	ME231	6	Compulsory
Manufacturing Processes – I	ME251	6	Compulsory
Thermodynamics	ME111	6	Optional
Fluid Mechanics	ME212	6	Optional

The student must earn a minimum of 18 credits from the above-prescribed courses. Apart from this, six more credits could be earned by registering to any other courses within the department (ME).

Discipline of Chemistry

Students admitted to course-based BTech (Honours) in the department of Chemistry will take the following courses as per the requirement of the program.

Course Name	Course Code	Credit	Compulsory/Optional
Quantum Chemistry	CY501	6	Compulsory
Bioinorganic Chemistry	CY509	6	Compulsory
Advance Organic Chemistry	CY605	6	Compulsory

Apart from this, six more credits should be earned by registering to any elective courses within the department (CY).

Discipline of Mathematics:

Students admitted to course-based BTech (Honours) in the discipline of Mathematics will take the following courses as per the requirement of the program.

Course Name	Course Code	Credit	Compulsory/Optional
Real Analysis	MA500	6	Compulsory
Numerical Techniques	MA507	6	Compulsory
Operations Research	MA605	4	Compulsory
Numerical Optimization Techniques	MA609	2	Compulsory

Apart from this, six more credits should be earned by registering to any of the elective courses within the department (MA).

Discipline of Physics

Students admitted to course-based BTech (Honours) in the discipline of Physics will take the following courses as per the requirement of the program.

Course Name	Course Code	Credit	Compulsory/Optional
Quantum Mechanics-I	PH502	6	Compulsory
Solid State Physics	PH512	6	Compulsory
Any Two Course from following Courses			
Statistical Physics	PH506	6	Optional
Electrodynamics	PH508	6	Optional
Nuclear and Particle Physics	PH509	6	Optional
Mathematical Physics	PH503	6	Optional

Master of Science (MSc)

MSc program at IIT Bhilai will be offered starting from 2019-20-M semester in three disciplines.

1. Chemistry,
2. Mathematics and Computing, *and*
3. Physics.

General Structure of MSc program

The MSc program offered at IIT Bhilai is a fully residential program with a nominal duration of 2 years. Accordingly, the minimum credit requirements for students in various categories of courses to become eligible for the award of MSc Degree from IIT Bhilai is as follows.

S. No.	**Category**	**Minimum Credits**
1.	PC	72
2.	DE/OE	12
3.	Thesis	24
Total (Minimal requirement)		**120**

The discipline-wise curriculum MSc of program is mentioned in the following sections.

Discipline of Chemistry

Semester I

Course Name	Course Code	Credits
Quantum Chemistry	CY501	4
Mathematics for Chemists / Introduction to Biochemistry	CY516 / CY517	4
Chemical Kinetics and Surface Science	CY502	4
Coordination Chemistry	CY503	6
Chemistry of Main Group Elements	CY504	6
Organic Reactions and Reagents	CY505	6
Total Credits		**30**

Semester II

Course Name	Course Code	Credits
Statistical Mechanics and Thermodynamics	CY507	4
Molecular Spectroscopy	CY508	4
Bioinorganic Chemistry	CY509	6
Stereochemistry and Reaction Mechanism	CY510	6
Physical Organic Chemistry	CY511	2
Organic Photochemistry	CY512	2
Computations in Chemistry	CY515	2
Physical Chemistry Practical	CY513	2
Organic Chemistry Practical	CY514	2
Total Credits		**30**

Semester III

Course Name	**Course Code**	**Credits**
Solid State Chemistry	CY604	4
Inorganic Chemistry Practical	CY506	2
Organometallic Chemistry: Principles and Applications	CY603	6
Interpretative Molecular Spectroscopy	CY607	6
Advanced Organic Chemistry	CY605	6
Thesis	CY699	6
Total Credits		**30**

Semester IV

Course Name	**Course Code**	**Credits**
Departmental Elective	-	6
Departmental Elective	-	6
Thesis	CY699	18
Total Credits		**30**

Discipline of Mathematics and Computing

Semester I

Course Name	**Course Code**	**Credits**
Real Analysis	MA500	6
Linear Algebra	MA501	6
Modern Algebra	MA502	4
Introduction to Probability Theory	MA503	4
Differential Equations	MA504	4
Introduction to Programming	IC100	6
Total Credits		**30**

Semester II

Course Name	**Course Code**	**Credits**
Complex Analysis	MA505	6
Multi-Variable Calculus	MA506	4
Numerical Techniques	MA507	6
Topology	MA508	6
Discrete Structures I	CS101	4
Data Structures	CS102	4
Total Credits		**30**

Semester III

Course Name	**Course Code**	**Credits**
Functional Analysis	MA604	6
Operations Research	MA605	4
Numerical Optimization Techniques	MA609	2
Departmental Elective	-	6
Open Elective	-	6
Thesis	MA699	6
Total Credits		**30**

Semester IV

Course Name	**Course Code**	**Credits**
Departmental Elective	-	6
Open Elective	-	6
Thesis	MA699	18
Total Credits		**30**

Discipline of Physics

Semester I

Course Name	**Course Code**	**Credits**
Classical Mechanics	PH501	6
Quantum Mechanics-I	PH502	6
Mathematical Physics	PH503	6
Computational Physics	PH504	6
Electronics Laboratory	PH505	6
Total Credits		**30**

Semester II

Course Name	**Course Code**	**Credits**
Statistical Mechanics	PH506	6
Quantum Mechanics-II	PH507	6
Electrodynamics	PH508	6
Nuclear and Particle Physics	PH509	6
Experimental Laboratory	PH510	6
Total Credits		**30**

Semester III

Course Name	Course Code	Credits
Atomic and Molecular Physics	PH511	6
Solid State Physics	PH512	6
Experimental and Measurement Techniques	PH513	6
Departmental Elective	-	6
Thesis	PH699	6
Total Credits		**30**

Semester IV

Course Name	Course Code	Credits
Departmental Elective	-	6
Departmental Elective	-	6
Thesis	PH699	18
Total Credits		**30**

Master of Technology (MTech)

MTech program in IIT Bhilai is currently being offered in the following six disciplines.

1. Computer Science and Engineering,
2. Data Science and Artificial Engineering,
3. Electric Vehicle Technology,
4. Electrical Engineering,
5. Mechanical Engineering, *and*
6. Mechatronics

General structure of MTech program

MTech program in IIT Bhilai had a nominal duration of 21 months with a minimum residential requirement of one regular semester.

The minimum credit requirements for students in various categories of courses for the award of MTech Degree from IIT Bhilai is provided in the following table.

S. No	Category	Minimum Credits
1.	IC	6
2.	DE	18
3.	Thesis	48
Total (Minimal requirement)		**108**

The curriculum for MTech program is common across the disciplines, which is defined hereunder.

Semester I

Course Name	Course Code	Credits
Research Methodology	IC601	6
Departmental Electives	-	18
Total Credits		**24**

Semester II onwards

Course Name	Course Code	Credits
Departmental Electives / Thesis	-	24
Total Credits		**24**

Summer Semester

Course Name	Course Code	Credits
Departmental Electives / Thesis	-	12
Total Credits		**12**

Doctor of Philosophy (PhD)

IIT Bhilai offers PhD degree program in the following disciplines.

- Chemistry,
- Computer Science and Engineering,
- Data Science and Artificial Intelligence,
- Electric Vehicle Technology,
- Electrical Engineering,
- Mathematics,
- Mechanical Engineering,
- Mechatronics,
- Physics, *and*
- Liberal Arts.

General structure of PhD program

Candidates are admitted to PhD program in IIT Bhilai either after completion of Under-Graduate (UG) or Post-Graduate program subject to fulfilling the other eligibility criteria defined by the Institute. Further, the PhD program is offered under two different modes with the nominal duration mentioned as below.

1. Full-time – Nominal program duration of 3 years for students admitted after PG and 3.5 years for students admitted after UG.
2. Part-time – Nominal program duration of 4.5 years for students admitted after PG and 5 years for students admitted after UG.

Accordingly, the minimum credit requirements for students in various categories of courses for the award of PhD Degree from IIT Bhilai is provided in the following table.

S.No	**Category**	**Minimum Credits**	
		After PG	**After UG**
1.	IC	6	6
2.	DE	18	42
3.	Thesis	108	108
Total (Minimal requirement)		**168**	**192**

The curriculum for PhD program is common across the disciplines which is defined hereunder.

Semester I

Course Name	Course Code	Credits
Research Methodology	IC601	6
Departmental Electives	-	18 (12*)
Total Credits		**24 (18*)**

* For part-time students

Semester II onwards

Course Name	Course Code	Credits
Thesis / Departmental Electives #	-	24 (18*)
Total Credits		**24 (18*)**

Students admitted after UG are required to opt for 24 credits of courses.
* For part-time students

Summer Semesters

Course Name	Course Code	Credits
Thesis / Departmental Electives	-	12 (6*)
Total Credits		**12 (6*)**

* For part-time students

Part B: Course Contents

Institute Core Courses

IC100 Introduction to Programming (6 Credits)

Basics of programming using an appropriate language; Basic UNIX commands; Arithmetic operations; Data Types; Input and output functions; Conditionals; Loops; Function constructions; Recursion; Arrays; Pointers; Strings; Classes; File handling; Object oriented programming.

Prerequisites: NA

IC101 Digital Fabrication (6 Credits)

Freehand sketch: Orthographic, isometric projections, surface development, Familiarization with 3D solid modeling (CAD) for the creation of engineering and freeform geometries, 3D Scanning using CMM and laser scanners, 3D Printing for conversion of CAD model into a real part (additive manufacturing process): slicing, effect of part orientation, Familiarization with conventional machining processes: Centering, drilling, and milling using tabletop reconfigurable CNC machines, Familiarization with Casting and molding, Demonstration of Laser cutting machine.

Prerequisites: NA

IC102 Electromagnetism (2 Credits)

Vector algebra, Coordinate systems, Vector analysis, Maxwell's equations, Maxwell's equations in matter, Boundary conditions, Continuity equation, Poynting's theorem, Newton's third law in Electrodynamics, Maxwell's stress tensor, Conservation of Momentum, angular momentum, Electromagnetic waves in vacuum, Electromagnetic waves in matter, absorption and dispersion, Guided waves.

Prerequisites: NA

IC103 Materials Chemistry I (2 Credits)

Introduction to functional polymer materials with respect to types of polymers and their nomenclature; polymer synthesis; molecular weight determination; physical properties of polymers; applications of polymeric materials in everyday life. Introduction to bio-materials: amino acids, peptides, proteins, enzymes, carbohydrates, nucleic acids and lipids. Peptide-polymer conjugates: synthesis properties and applications.

Prerequisites: NA

IC104 Linear Algebra I (3 Credits)

Systems of linear equations, elementary operations, row-reduced echelon matrices, Gauss elimination, LU factorization, linear independence, rank of a matrix, solutions of linear systems: existence and uniqueness, vector spaces, subspaces, spanning space, bases and dimensions, linear transformations, matrix representations of linear transformations, range

space and rank, null space and nullity, the rank and nullity theorem, invertibility.

Computer lab by using appropriate software tools like Python, MATLAB etc.

Prerequisites: NA

IC105 Probability and Statistics (4 Credits)

Probability spaces, conditional probability, Bayes' theorem; random variables, probability distribution functions, joint distributions, independence, mathematical expectations, Chebyshev's inequality; special distributions: binomial, hypereometric, Poisson, exponential, uniform, normal distributions. Random sampling, sample mean, sample variance, weak law of large numbers and central limit theorems; estimation of parameters, the method of maximum likelihood estimation, confidence intervals, testing of hypotheses, goodness of fit, nonparametric tests, correlation analysis.

Prerequisites: NA

IC106 Chemistry Lab (3 Credits)

A laboratory course designed to give an overview of the fundamental principles of organic, inorganic and physical chemistry. Experiments include synthesis of aspirin, estimation of phenol, qualitative analysis of an organic compound, estimation of copper in brass, determination of hardness of water, reaction kinetics, formation constant of KI_3, acid strength of a citrus fruit and estimation of sodium oxide in cement.

Prerequisites: NA

IC107 Physics Lab (3 Credits)

1. Studying Hall effect and Measure Hall coefficient, carrier density, and carrier mobility in semiconductor.

2. Studying Gouy's method and measure magnetic susceptibility in Aluminium.

3. Studying interference principle and measure wavelength of light by observing Newton's rings.

4. Studying Diffraction principle and measure slit width of single wire, cross wire and grating.

5. Studying energy bandgap theory and measure energy bandgap of silicon and germanium Diode.

6. Studying Zener Diode and Stefan's Law.

7. Studying application of Cathode Ray Oscilloscope (CRO) and measure voltage, Frequency and observe superposition principle.

8. Studying characteristics of a npn transistor.

Prerequisites: NA

IC150 Applied Digital Logic Design (6 Credits)

Introduction to FPGA and Hardware Description Languages (HDLs), Combinational Circuits – Logic gates, Boolean Algebra, gate-level minimization, Circuit design and implementation, Adders, Comparators, Multiplexers, Decoders/encoders, Applications, Data storage elements

– Latches, Flip-Flops, Register, Memory, Applications, Sequential Circuits – State tables and diagrams, State representation in HDLs, Timing in sequential circuits, Shift register, Counters.

Prerequisites: NA

IC151 Quantum Physics (2 Credits)

Classical to quantum cross-over, basic principles of quantum mechanics, wave function and uncertainty principle, probability wave amplitude, probability density, wave equation and Schrodinger formalism, time-independent and time-dependent Schrodinger equations, Dirac formulation of quantum mechanics, linear vector spaces, bra and ket vectors, completeness and ortho-normalization of basis vectors, basis sets, change of basis, eigenstate and eigenvalues, expectation values.

Prerequisites: NA

IC152 Linear Algebra II (3 Credits)

Eigenvalues, eigenvectors and some applications of eigenvalue problems, Hermitian, skew-Hermitian, unitary matrices and their eigenvalues; eigenbases, diagonalization, annihilating polynomial, the minimal polynomial and the characteristic polynomial, Cayley-Hamilton theorem; Inner product spaces, orthonormal bases, Gram-Schmidt process.

Computer lab by using appropriate software tools like Python, MATLAB etc.

Prerequisites: NA

IC153 Calculus I (3 Credits)

Real number system, convergence of a sequence, Sandwich theorem, Cauchy sequences, subsequence, monotone sequences, monotone convergence theorem; convergence of infinite series, comparison test, Cauchy condensation test, ratio test, root test and Leibnitz test; limits and continuity of functions, intermediate value property, differentiability of a function, local maxima and minima, Rolle's theorem, mean value theorem and applications.

Definite integrals as a limit of sums, fundamental theorems of calculus, applications of definite integrals to area, volume, surface area, improper integrals.

Prerequisites: NA

IC200 Introduction to Astronomy and Astrophysics (4 Credits)

Overview - Scales and Dimensions, Night Sky, Constellations, Earth, Sun, and the Solar System, Retrograde Motion of Planets, Sidereal Time.

Observations- Electromagnetic Waves, Electromagnetic Spectrum, Telescopes, Refractor Telescope, Reflecting Telescope, Observations at Visible Frequencies, Theoretical Limit on Resolution, Mounting of Telescope, Equatorial Mount, Azimuthal Mount, Interferometer, Observations at Other Wavelengths. Astrometry - Coordinate Systems, Doppler Effect, Parallax, Aberration, Precession of Equinoxes, Equatorial Mounting of a Telescope Star Formation and Stellar Evolution - Stellar Nuclear Reactions, White Dwarfs, Neutron Star, Black Holes, Supernova

Cosmology - Big Bang Cosmology, Cosmological Red shift and Hubble's Law, Matter and Radiation, Accelerating Universe and Dark Energy, The Early Universe, Primordial Nucleo synthesis, Cosmic Microwave Background Radiation (CMBR)

Particle Physics and High Energy Physics

The Standard model of particle physics, elementary particle classification, fermions and bosons, electromagnetic, weak and strong processes. Introduction Large Hadron Collider.

Prerequisites: NA

IC201 Environmental Studies (2 Credits)

Understanding our environment (atmosphere composition and behaviour, ecosystem, flow of energy and nutrient cycles, sustainability), global warming (greenhouse gases, results of global warming), brief overviews of ozone depletion and atmospheric pollutants. Organic and Inorganic chemicals in environment (toxicity, polychlorinated hydrocarbons like DDT, polymers, detergents) and their impact on environment, a project on environment related topic.

Prerequisites: NA

IC202 Calculus II (3 Credits)

Continuity, partial derivatives, directional derivatives, gradient, differentiability, chain rule; tangent planes and normals, maxima and minima for function of two variables, Lagrange multiplier method; double and triple integrals with applications to volume, surface area, moments of inertia, change of variables; vector fields, line integrals, Green's theorem and its applications, path independence; surface integrals, evaluation, Gauss's divergence theorem and its applications.

Prerequisites: NA

IC250 Materials Chemistry II (2 Credits)

Organic/Inorganic Hybrid Materials: design, synthesis and characterization, properties, applications, Organometallic materials, Materials for energy storage systems and fuel cells, Materials for redox flow batteries, Cluster compounds.

Prerequisites: NA

IC251 Basics of Bioinformatics (4 Credits)

Introduction to biomolecules (amino acids, proteins, DNA, RNA, Genes) and different tools to visualize and represent biomolecules on computer (Visual molecular dynamics (VMD) software)

General introduction to bioinformatics; Definition, Scope and applications, brief history of sequence analysis - Protein, DNA and RNA sequences; introduction to different bioinformatics related databases (EMBL, DDBJ, GenBank, PIR, PDB etc.) and their uses.

Sequence analysis - Comparing two sequences, Similarity searches on sequence databases, building multiple sequence alignment, local and global alignment, BLAST, FASTA.

Working with 30 protein structures - introduction to protein data bank (PDB) file, predicting the secondary structure of a protein sequence, primary structure to 30 structure of protein, finding

proteins with similar shapes, folding a protein in a computer, predicting interactions; working with RNA.

Prerequisites: NA

IC300 Materials Chemistry III (2 Credits)

Introduction to light harvesting materials (organic, inorganic and hybrid materials), semiconductor basics. Light-matter interaction (black body radiation, photoelectric effect, wave-particle duality, concept of wave function, particle in 1D box). Applications of semiconductor systems and solar-cells, conjugated polymers (coupling reactions), inorganic (quantum dot synthesis and properties) and hybrid semiconductors (advanced synthetic protocols).

Prerequisites: NA

IC601 Research Methodology (6 Credits)

Literature search, review and citation practices Problem identification, formulating research questions Quantitative and qualitative methods – strengths and weaknesses Instrumentation and data logging, Data sampling, collection, testing Data analysis, interpretation and limitations, Validity, reliability, sources of error, Data management and presentation.

Prerequisites: NA

Courses in Creative Arts and Liberal Arts

CA100 Professional Communication Lab I – Sketching and Drawing (1 Credits)

Drawing as a means of visual organization. Emphasis on drawing fundamentals of proportion, composition, and layout. Subject matter and medium vary.

Prerequisites: NA

CA106 Madhubani Painting (2 Credits)

1. Introduction of Madhubani Painting
2. Drawing: -Uses of traditional tools, Border making technique, Main Image drawing and background filling
3. Design making process
4. Colour making process (Natural & Acrylic colour)
5. Introduction of Madhubani painting on fabric.

Prerequisites: NA

CA107 Understanding Kathak (2 Credits)

1. Origin of Kathak – Its Journey
2. Emergence of Gharanas – Differences with Practical Demonstration
3. The Various Socio cultural Influences on Kathak
4. Kathak and Natyashastra
5. Bhava and Rasa in Kathak
6. Influence of Wajid Ali Shah
7. Contribution of Kathak to Hindusthani Classical Music
8. Sufi in Kathak
9. Secular Aspect of Kathak
10. Kathak and Dhrupad
11. Concept of Dance Theatre in Kathak
12. Physiological and Psychological – Impact of Dance and Correlation

Prerequisites: NA

CA108 Folk Theatre of India (2 Credits)

1. General Introduction:
2. Origin of Indian Drama- various sources- Sanskrit drama/Folk drama
3. Understanding concept of space in drama, acting, human body, films etc
4. Improvisation - theatre games, acting
5. Making stories- on two dimension spaces like painting etc; on three dimension
6. spaces - performance

7. Working in groups - creating as a group - presentation as a team

Prerequisites: NA

CA109 Sculpture Design (2 Credits)

1. Introduction to Sculpture:
    - o Definition of Sculpture
    - o Method of Sculpture
    - o Main mediums of Sculpture
    - o Fundamentals of art (visual art)
2. Practical
    - o Drawing: Study of human and Animal forms and imaginative drawings
    - o Clay modelling
    - o Clay modelling of any human and animal
        - o Form- architectures and geometrical form.

Prerequisites: NA

CA110 Fundamentals of Hindustani Music (2 Credits)

1. Introduction of seven shuddha & five vikrit swaras.
2. Five Alankaras in shuddha swaras.
3. Swarmalika (Sargam Geet) in Raga Yaman, Bhairav, Kati and Bhairavi.
4. Chhota khayal in Raga Yaman, Bhairav, Kati and Bhairavi.
5. Light compositions in above ragas.
6. Knowledge of Dadras, Kaherwa and Trital with hand gesture.

Prerequisites: NA

CA111 Understanding Cinema (2 Credits)

1. Participative Learning
2. A combination of discussion and screenings
3. Ranging from a brief introduction to Cinema, a 100 year old art form to the growth and development of cinema globally, and in India.
4. The difference between genres.
5. Why Cinema: at the end of the course, the students are expected to have deepened their understanding of the visual as text, and communication.

Prerequisites: NA

CA150 Professional Communication Lab II- Presentations Skills (1 Credits)

Need of presentation skills for Engineers; Modes of presentation - writing, speaking, demonstrating;
Writing - reports, papers, reviews; Document structuring - Sections, footnotes, captions, cross reference, etc.
Speaking - workshops, conferences, interviews; Discussion - Ideation, pitching the ideas, Ideation to formulation.
Demonstrating -slides, videos, models, prototypes; Visual appeal - Usage of proper fonts, styles, colours, etc.

Effective presentation strategies; dos and don'ts.

Prerequisites: NA

CA200 Professional Communication Lab III – Technical Literature Structure (1 Credits)

Usage of appropriate language in technical communication - Types of scientific writings - Abstract writing - Technical report writing - Review writing – Online communication.

Prerequisites: NA

CA250 Professional Ethics (2 Credits)

1. The values of professional ethics.
2. Foundations and norms of professional ethics.
3. The nature, scope and challenges of professions.
4. Code of conduct for professionals.
5. Obligation to clients, colleagues and third parties.
6. Breach of confidentiality and trust.
7. Relation between professional and general ethics.
8. The nature of engineering ethics, the value of ethnical practices in engineering.
9. Certain specific issues pertaining to medical ethics, legal ethics, environmental ethics, computer ethics and business ethics.

Prerequisites: NA

LA301 What is Literature (2 Credits)

What is literature? Use of literary conventions, who are in the literature (hero, villain, stock characters), Storytelling traditions in India (folk lores, Ramayana, Mahabharata)

Prerequisites: NA

LA302 Indian Writing in English (4 Credits)

Nationalism: migration; regionalism; history; diaspora, Gender and sexuality: womanhood; masculinity; agency Caste: access; representation; triple jeopardy Urbanisation: inequality; the everyday; aspiration.

Prerequisites: NA

LA303 Chinese Language Beginner I (1 Credits)

This course aims to introduce basic knowledge of Chinese to students with Chinese phonetics background. The course will cover (1) daily topics, (2) basic grammatical structure such as word order, questions, negation and so forth, and (3) writing Chinese characters.

Prerequisites: NA

LA305 City in Literature (4 Credits)

Treating the written text as a vital artefact reflecting spatial, historical, sociological, and political underpinnings of urbanisation in our times, this course will be structured around the following modules:

1. Planning and its Imprints
2. Public Space and Individuality
3. Experiencing the Small Town
4. Imaginations of Home
5. Risk and the Uncanny
6. Romance in/with the City

Prerequisites: NA

LA308 Positive Psychology (2 Credits)

Positive Psychology brought a change in the traditionally dominant perspective of studying illness to studying prevention of illness within psychology. This course will introduce students to the study of overall well-being. It will provide information about the philosophical and historical roots of positive psychology and the study of well-being. Following an introduction to theories of well-being in this domain, students will explore the concepts of individual character strengths and virtues and the application of these concepts in daily lives. This information will then be applied to gain an understanding of how work-place well-being can be enhanced.

Course Topic:

1. Introduction and brief overview: Shift from the traditional deficit approach to the strengths approach
2. History of well-being research; Overlaps among well-being concepts; Theories - hedonism- eudaimonism, authentic happiness- pleasant, engaged, and meaningful life, PERMA, broaden-and-build, structure of psychological wellbeing; Contributors to well-being - Genetics, circumstances, actions; VIA Classification: Character strengths and virtues (any three/four strengths in detail)
3. The positive side of negative emotions- Resilience and defensive pessimism
4. Assessment of well-being: Tools, methodological constraints, accepted indicators
5. Applications of positive psychology techniques- positive psychology interventions exercises, and practice.
6. Criticism and future of positive psychology.

Prerequisites: NA

LA309 History of Epigraphy and Numismatics (1 Credits)

1. What is Epigraphy?
2. What is Numismatics?
3. Epigrpahy Numismatics and Multidisicplinary Studies
4. Contents of Inscriptions
5. Coins and their scientific analysis

Prerequisites: NA

LA310 History of Medicine and Surgery (1 Credits)

1. Nature of Medical Literature in Ancient India
2. The two major Samhitas
3. Doctors and Quacks
4. History of Plastic Surgery in Ancient India

5. Four Physicians of the Past

Prerequisites: NA

LA311 Chinese Language Beginners 3 (2 Credits)

This course aims to introduce basic knowledge of Chinese to students with Chinese learning background. The course will cover (1) more daily topics, (2) more family terms and titles, (3) expressing individual preferences and abilities, (4) basic grammatical structure such as more measure words, “duo” as an indefinite number and so forth, and (5) writing Chinese characters.

Prerequisites: LA303 and LA315

LA312 Chinese Language Beginners 4 (2 Credits)

This course aims to introduce basic knowledge of Chinese to students with Chinese learning background. The course will cover (1) expressing places, locations, and movement, (2) the relationship between time and the progress of actions, (3) basic grammatical structure such as complex sentences, “shi…de” sentence and so forth, and (4) writing Chinese characters.

Prerequisites: LA303, LA312 and LA315

LA313 Chinese Language Beginners 5 (2 Credits)

This course aims to introduce basic knowledge of Chinese to students with Chinese learning background. The course will cover (1) the relationship between work, rest and time, (2) expressing seasonal and climate situations, (3) basic grammar such as aspect particle and so forth, and (4) writing Chinese characters.

Prerequisites: LA312

LA314 Communication in Chinese (1 Credits)

This course aims to train students’ oral expression skills. The course will cover (1) all kinds of situations for daily topics, (2) expressing students’ opinions, (3) having basic concept to know between the words and the lines, and (4) some buzzwords.

Prerequisites: NA

LA315 Chinese Language Beginners II (1 Credits)

This course aims to introduce basic knowledge of Chinese to students with Chinese learning background. The course will cover (1) more daily topics, (2) family terms and titles, (3) expressing individual preferences and abilities, (4) basic grammatical structure such as more measure words, "you" sentence and so forth, and (5) writing Chinese characters.

Prerequisites: NA

LA316 Chinese Language Phonetics (1 Credits)

This course aims to introduce basic knowledge of Chinese to students with no Chinese learning background. The course will cover (1) phonetic and spelling of Chinese, (2) greeting, (3) small numbers (from 1 to 99), and (4) classroom phrases.

Prerequisites: NA

LA317 The Psychology of Memory (2 Credits)

1. Cognition
2. Understanding memory
3. Theories of memory
4. Types of memory
5. Forgetting
6. Mnemonics
7. Applications of memory in Law, clinical psychology, education

Prerequisites: NA

LA318 Chinese Basic 1 (1 Credits)

This course aims to introduce basic knowledge of Chinese to students with Chinese learning background. The course will cover (1) how to explain vacation plans, (2) explaining a country's geographic locations and introducing simple distinguishing features of the terrain, (3) basic grammar and (4) writing Chinese characters.

Prerequisites: LA313

LA319 Chinese Basic 2 (1 Credits)

This course aims to introduce basic knowledge of Chinese to students with Chinese learning background. The course will cover (1) how to order food, (2) telephone conversations, (3) basic grammar and (4) writing Chinese characters.

Prerequisites: LA318

LA320 Chinese Basic 3 (1 Credits)

This course aims to introduce basic knowledge of Chinese to students with Chinese learning background. The course will cover (1) comparative sentences, (2) asking others for assistance, (3) basic grammar and (4) writing Chinese characters.

Prerequisites: LA319

LA321 Macroeconomics (2 Credits)

1. Macroeconomic data, GDP concepts.
2. Money demand and money supply, role of central bank, inflation.
3. Unemployment, The economy in the short run: Aggregate Demand-Aggregate supply (AD-AS) model.
4. Aggregate Demand in a closed economy: Building and applying the IS-LM model.
5. Aggregate Demand in the open economy: the open economy IS-LM model and the exchange rate regime.
6. The open economy and exchange rate dynamics

Prerequisites: NA

LA322 Microeconomics (2 Credits)

1. Economic way of thinking, important core principles of economics,

2. Basics of demand and supply, consumer behavior, price elasticities, government pricing
3. policies of tax and subsidy
4. Industrial production and costs, market structures such as perfect competition, monopoly,
5. imperfect competition and oligopoly,
6. Product pricing strategies of companies.

Prerequisites: NA

LA323 Introduction to Popular Culture (2 Credits)

1. What is 'culture' - compare Arnold's and Williams' ideas of it
2. 'high' vs. 'low' culture- 'popular culture' - definitions and debates
3. Different kinds of constituents of popular culture - mass media products, practices,
4. objects, people, places etc.
5. How to 'read' texts critically - both text as itself and text with context.
6. Popular culture and the 'common sense' of society.

Prerequisites: NA

LA324 Leadership: An Organizational Behaviour Perspective (2 Credits)

1. Introduction to organizational behavior.
2. Understanding the nature of leadership.
3. Approaches to leadership- trait, behavioural and contingency approaches
4. Leaders and followers- leader-member exchange model, dynamics of in-group versus outgroup
5. Decision Theory: Vroom and Yetton's Leader Participation Model
6. Leadership development
7. Global implications

Prerequisites: NA

LA325 Concepts of Personality Psychology (2 Credits)

1. Introduction to Personality Psychology
2. Introduction to Schools of Personality Psychology
3. Selected Trait and type approaches
4. Psychoanalysis and Psychodynamic approaches
5. Behavioristic Approach
6. Humanistic Approach
7. Assessment of Personality

Prerequisites: NA

LA326 Adaptation: Literature and Beyond (2 Credits)

8. Define and differentiate between adaptation, appropriation and intertextuality
9. Adaptation as product and process
10. Adaptation across literary genres: Kolatkar's Sarpa Satra
11. Intermedial adaptation: Hamlet on film
12. Cultural adaptation: Nina Paley's Sita Sings the Blues

13. Discussion on various adaptations of writers including Shakespeare and Austen,
14. and the Indian epics.

Prerequisites: NA

LA327 Introduction to Partition Literature (2 Credits)

1. Mapping out partition literature
2. Historical perspective on the partition of Punjab and Bengal
3. Remembrance and trauma expressed in literature
4. Representations of the partition in some popular films

Prerequisites: NA

LA328 Economic Development in India (2 Credits)

1. India's economic growth and development experience since Independence
2. Current issues in economic growth
3. Poverty alleviation and income inequality
4. Indian labour (job) market: current issues and prospects
5. Education in India: progress and problems
6. Healthcare in India: progress and problems
7. Current issues and problems in the unorganized/informal sector
8. Developments and problems in the agriculture sector

Prerequisites: NA

LA329 Selected Topics on Indian Economy (2 Credits)

1. Introduction to the Indian economy, growth and development experience thus far, the 1991 Economic Liberalization
2. The Industry sector: issues and prospects
3. Developments in banking and financial markets
4. Fiscal policy, Government of India's Annual Budget
5. Progress and problems in the Agriculture sector
6. The Services sector: issues and prospects
7. Developments in international trade sector

Prerequisites: NA

LA330 Chinese Conversation (1 Credits)

Being able to express one's idea and feeling is very important when it comes to foreign language learning.

This course aims to:

(1) Correct pronunciations and tones

(2) Conversation with different scenarios

(3) Encourage students to create more vivid conversations

(4) Potential topics: greeting, asking information, in restaurants, travelling, expressing needs ..... etc.

Prerequisites: Chinese Beginner 3

LA331 Chinese Writing (1 Credits)

This course aims to introduce basic writing skill of Chinese to students with Chinese learning background. This course will cover basic writing skills and article structure analyses. The potential topics:
(1) formal self-introduction I brief biography in Mandarin
(2) CV form in Mandarin
(3) Writing about ambition
(4) studies in IIT Bhilai and
(5) characters writing practice.

Student will choose 1 or 2 topics according to their preference.

Prerequisites: Chinese Beginner 5

LA332 Chinese Culture (1 Credits)

Chinese culture is one of the world's oldest cultures, originating thousands of years ago. The area over which the culture prevails covers a large geographical region in East Asia and is extremely rich with customs and traditions varying greatly between provinces, cities, and even towns as well. Chinese civilization is historically considered the dominant culture of East Asia. With China being one of the earliest ancient civilizations, Chinese culture exerts profound influence on many aspects to date.

This Course aims to introduce:

(1) Philosophy, virtue, and etiquette system.

(2) Cuisine and tea art.

(3) Clothing, dance and music.

(4) Chinese New Year.

Prerequisites: NA

LA333 Chinese Calligraphy (1 Credits)

Chinese calligraphy is a type of pleasing writing, as well as a kind of sport, embodying the artistic expression of human language in a tangible form. This type of expression has been widely practiced in China and has been generally held in high esteem across East Asia. Calligraphy is considered as one of the four best friends of ancient Chinese literati.
This course aims to introduce:
(1) History of Chinese calligraphy
(2) Tools for Chinese calligraphy
(3) Strokes in Chinese calligraphy
(4) Practice Chinese calligraphy with students' Chinese names
(5) Practice writing short spring rolls (good phrases used in Chinese New Year)

Prerequisites: NA

LA334 Themes in Literature (2 Credits)

Introduction to various themes in literature.

1. self-reliance and individualism
2. the American Dream
3. marginalized perspectives
4. women and self-expression
5. reinvention of mythology

Prerequisites: NA

LA335 Economic Growth: Theory and Applications (2 Credits)

1. Macroeconomic data, GDP concepts
2. History of economic growth in India and the world
3. Classical growth models
4. Solow's neoclassical growth model, theory and empirics
5. Romer's endogenous growth theory and empirics
6. Modem growth theories: Political institutions and economic growth (Acemoglu, Alesina, Besley etc.), corruption and growth
7. Political economy of India's growth experience

Prerequisites: NA

LA336 Pricing Strategy (4 Credits)

1. Introduction and overview of the course, strategic pricing

Product pricing of private firms

2. Pricing under different market structures such as monopoly and oligopoly
3. Economic value to the customer (value creation, customer-based pricing)
4. Price sensitivity of demand and supply, demand analysis using regression
5. The role of costs and cost-plus pricing (cost-based/company-centric pricing), pricing for profit, breakeven analysis
6. Competition based pricing
7. Price discrimination, segmentation and product line pricing
8. Psychology of pricing, price perceptions and behavioral pricing
9. Strategic pricing schemes such as dynamic pricing, predatory pricing
10. Ethical issues of pricing, business ethics
11. Basics of auctions as a price discovery mechanism
12. Pricing of new products

Role of government and others

13. Government pricing laws and regulations, and policies of tax and subsidy
14. Negotiating regulation and firms' market power
15. Pricing and international business

Prerequisites: NA

LA337 Entrepreneurship and Startups (4 Credits)

Introduction and overview of the course

(a) Ideation, innovation and start-up issues:

Generating and evaluating venture ideas, disruptive and open innovation, opportunity recognition and entry strategies (new product, franchising, and acquisition)

Creation and protection of intellectual property; and legal issues, power and money among founders (initial organizational culture)

Business model: developing an initial business plan, lean startups

Entrepreneurial financing: early-stage valuations of startups; matching stage with financing

types (debt, venture capital and other forms)

Entrepreneurial marketing and sales strategies, advertising and communications strategy Competitive business and pricing strategies for the new product, product and company launch

(b) Venture life cycle issues (after the start of the business)

Issues appearing at various stages: development, survival, rapid growth, and maturity.

Sustaining and reinforcing the competitive advantage

Negotiating with government regulation and policies

Managing growth and scaling up the business

The changing role and mid-career dilemmas of the founder entrepreneur

Exit strategies, harvesting and go-for-growth strategies

Issues faced in social entrepreneurship (optional)

(c) Company registration and corporate processes for startups in India

Course wrap-up

Prerequisites: NA

LA338 Childhood, Adolescence and Youth in Modern Short Fiction (2 Credits)

1. Comparing and contrasting socio-cultural context(s) through a story's setting. (Customs, mannerisms, speech, etc., geographic, historic, and social conditions)
2. Understanding the narrative voice and the child's point of view. (First-person and third-person narrative, the innocent eye or the nalve narrator, the limited and the omniscient narrator)
3. Analyzing the development of themes through the child/adult interaction. (Uncovering the moral(s) of the story and figures of speech, e.g. symbols, allusions, etc.)
4. Tracing character development and the assimilation of gender norms. (Physical and psychological representation of the characters, protagonist v/s antagonist, etc.)
5. Representations of the coming-of-age through plot development. (Main aspects of the plot and the various forms of conflict)

Prerequisites: NA

LA339 Financial Economics (2 Credits)

Basic concepts: cashflow; discounting; present and future values; internal rate of return; principal and interest; arbitrage; financial instruments and markets.

Fixed-income securities: bond prices and yields; interest rate sensitivity; duration; immunization; the term structure of interest rates; yield curves; spot rates and forward rates; other fixed-income securities.

Stock market: asset returns and risks; efficient market hypothesis; Markowitz model; capital asset pricing model (CAPM); investment analysis and asset pricing.

Derivatives: Hedging; forward contract, futures contracts, options, types of options.

Prerequisites: NA

LA340 Public Finance (2 Credits)

1. Introduction to public finance, India's fiscal policy and budgeting
2. Public goods, cost-benefit analysis
3. Externalities: issues and remedies
4. Elections, models of voting, democracy
5. Income redistribution, social security, public healthcare
6. Equity and efficiency implications of taxation
7. Personal income tax, effect of taxes on labour supply and savings
8. Indirect (commodity) taxes, corporate taxation.

Prerequisites: NA

LA341 Labour Economics (2 Credits)

Historic background and current issues in Indian labour Gob) market; Labour supply; Labour demand; Labour market equilibrium, wage structure, returns to education; Compensating wage differentials, human capital; Labour mobility; Labour market discrimination; Unemployment; Labour unions. labour market regulation

Prerequisites: NA

LA342 Economics of Information Technology (4 Credits)

Introduction, economics of information goods, services and platforms, economies of scale and scope, Hotelling differentiation; Network effects, switching costs, lock-in, strategic pricing of information products; Online price discrimination, bundling, versioning, freemium; Price conditioning, competition models; Game theoretic models of network traffic; Internet auctions; Complements and substitutes, platforms and two-sided markets, digital economy; Loci of competition, market power; Economics of information: regulation and network neutrality, free & open source software, value of information; Information asymmetries; Online privacy; Economics of information security, cybercrime, digital piracy, network cascades and social epidemics; Social network structure, network formation, peer production, memes, social bots; Cryptocurrencies, online labour market, cyberloafing; Internet governance and policy

Prerequisites: NA

LA343 Internet and Society (2 Credits)

Introduction, social issues involving life on the Internet, digital culture; Social networks, online publics, relationship formation; Social media and wellbeing, meaning-making, peer production, trolling, memes, social bots; Social media and politics, fake news, cyber activism, E-governance; Internet governance and policy: regulation and network neutrality, digital inclusion,Internet freedom, free & open source software; Online privacy, data ownership, surveillance; Cybercrime, digital piracy, information and communication ethics.

Prerequisites: NA

LA344 Introduction to English Romantic Poetry (2 Credits)

1. What is Romanticism? Contextualizing the poetry following the Age of Enlightenment and the French Revolution and its aftermath; the German idealism and the sturm and drang movement; individuality and society; rejection of industrialism in favour of nature, etc.
2. Close reading and critical analysis of Romantic poetry with reference to the prominent literary perceptions of the period (e.g. Wordsworth's 'Preface to the Lyrical Ballads', Keats' letters, and Shelley's 'Defence of Poetry', etc.).
3. Major characteristics of Romantic poetry: the role of imagination, nature, subjectivity, romantic sensibility, melancholy and nostalgia, the bi/dung and the child's growth, carpe diem, negative capability, etc.

Prerequisites: NA

LA345 Introduction to Classical Theatre (2 Credits)

1. Introduction to Ancient Greek and Roman Classical Theatre from a comparative approach.
2. Familiarization of ancient myths (e.g. Oedipus, Jason and Medea, the Trojan War etc.); understanding the relationship between human beings and the gods, between the sexes, master and slave, and between genres (e.g. tragedy and comedy).
3. Themes including sexuality, violence, conceptions of justice, and madness.
4. Importance of literature and relevance of the classical literary canon in the modem age.

Prerequisites: NA

LA346 Microeconomics 2 (2 Credits)

Overview on demand, supply and market equilibrium; Budget constraints: concept, properties, changes in budget constraints; Preferences: assumptions, utility, indifference curve, marginal rate of substitution, Cobb-Douglas function, optimal choice

Demand: Income offer curve and Engel curve, price offer curve and demand curve, inverse demand function, substitution effect, income effect.

Overview of imperfect markets and producer theory

Prerequisites: Microeconomics

LA348 The Individual and Society (2 Credits)

Relation between individual and society: Aristotle; Hobbes; Rousseau; Williams; the individual as "single example of a group" vs. as "fundamental order of being"; reading clusters focusing on the relation of the individual to the following socio-cultural themes: technology and social media; identity community; choice

Prerequisites: NA

LA349 Contemporary Indian Cinema: Beyond Bollywood (2 Credits)

Mapping the terrain of Indian cinema - a general introduction - mainstream vs. arthouse vs. regional; understanding Bollywood as "popular" Indian cinema - history, cultural significance, pan-Indian presence; the influence of globalisation and transregionalism on trends in Indian cinema with the 2010s as the period in focus, select movies exploring themes of:; Family; Love; The City; Community.

Prerequisites: NA

LA350 Political Economics (2 Credits)

Introduction to the economic analysis of political factors and outcomes. Economic and electoral impact of political factors. Democracy, dictatorship, government, political competition. Elections, models of voting, electoral politics in a democracy. History, political institutions and economic development. Corruption in public programs, bureaucracy, state capacity. Political economy of judiciary and news media.

Prerequisites: NA

LA351 Elements of World Literature (2 Credits)

1. The place of the literary text and the process of canonicity
2. The importance of translation in the context of world literature
3. Prize-winning authors and their impact on the literary field
4. Understanding world literature as a mode of reading and critical analysis
5. Tracing the various intercultural trajectories of the texts

Prerequisites: NA

LA352 Classics and Science (4 Credits)

This course presents a literary history of science, discussing the long history of craftsmanship and scientific thinking as reflected in literature. The course will:

1. Comment on the historical relationship between science, power, and poetry
2. Discuss the linkages between craftsmanship and society
3. Contextualise the socio-scientific milieu of the selected texts
4. Examine key instances of craftsmanship-such as building city defences, manufacturing armaments in selected texts

Prerequisites: NA

LA353 Experiencing the Indian University (2 Credits)

Navigating through a representative sample of Indian campus writing, this course encourages students to reflect on their own unfolding collegiate experience to form more cogent ideas of the university in India. It asks questions like:

1. Why and how do different institutions have different cultures?
2. How does teaching-learning happen in college campuses?
3. What are the challenges and rewards of peer groups?
4. How does one negotiate the pressures of assignments, exams, and placements?

Prerequisites: NA

LA354 Introduction to Postcolonial Literature (2 Credits)

1. Defining the key terms: colonialism, imperialism and postcolonialism
2. Understanding the many meanings and inflections of the term 'postcolonial'
3. Primary focus on literature that contends with the colonial legacy – including texts from South Asia, the Caribbean, Africa and Latin America.
4. Exploring the themes of freedom, nation, identity, migration and diaspora through these literary texts

Prerequisites: NA

LA355 Chinese Basic 4 (1 Credits)

This course aims to introduce intermediate level Chinese to students with Chinese learning background. This course will cover grammar and practice and encourage students to start combining previous knowledge into short article writing composition.

The potential topics:

1. Auxiliary verb in negative forms
2. Grammar construction by utilizing certain verbs
3. Verbal suffix
4. Time elapsed sentences
5. Short articles writing practice

Prerequisites: Chinese Basic 3

LA356 Chinese Basic 5 (1 Credits)

This course aims to introduce intermediate level Chinese to students with Chinese learning background. This course will cover grammar and practice. In continuance with writing practice, instructor shall reduce the frequency of utilizing English in class (if offline mode) to enhance students' listening ability.

The potential topics:

A. Resultative Compounds
B. Directional endings used as resultative endings
C. Verbal Compounds
D. listening Practice
E. Short articles writing practice

Prerequisites: Chinese Basic 4

LA357 Chinese Basic 6 (1 Credits)

This course aims to introduce intermediate level Chinese to students with Chinese learning background. This level targets on summarizing up Basic 1-6
The potential topics:

1. Reduplication of measure words
2. Reduplication of verbs
3. Passive sentences with Coverbs
4. Review of Basic level lesson 1-12

Prerequisites: Chinese Basic 5

LA358 Game Theory (2 Credits)

Introduction, background, rules, and examples

Symmetric games: Best response function, dominant strategies, Nash equilibrium, Iteratively eliminating dominated strategies, Mixed strategy, Cournot model, Bertrand model of duopoly, Auctions.

Extensive games: Strategies and outcomes, Nash equilibrium, Backward induction, Subgame perfect equilibrium, Finite and infinite repeated games, Stackelberg model of duopoly.

Prerequisites: NA

LA359 Introduction to Corporate Finance (2 Credits)

Valuation of stocks and bonds, risk-return trade-off, market efficiency and inefficiency, corporate financing- equity and debts, financial markets and institutions, Initial public offering, dividend distribution, capital structure, hedging, financial analysis, corporate mergers

Prerequisites: NA

LA360 Self and Society in Modern India (2 Credits)

Reading through autobiographies of select Indian scientists, sportspersons, authors, and activists,

this course proposes to critically reflect on the layered formation of self, society, and individuality in contemporary India. It will:

1. Explore the self as an evolving paradigm

2. Distinguish Indian notions of the personal and the public

3. Examine the role of privilege in identity formation

4. Analyse life writing as a form of reimagining the self

Prerequisites: NA

LA361 Introduction to Modern American Poetry (2 Credits)

1. Characteristics of modern poetry: representation of tradition and nature – intertextuality - feminism - masculinity- the poetic voice - modernism and the avant-garde - globalization.
2. Contextualizing modern poetry: historical and geopolitical contexts - migration - race - war - the Great Depression - McCarthyism - influence - reception – circulation

3. Close reading and critical analysis: scansion - simile, metaphor, personification -structure and rhyme scheme - speaker - repetition - allusion - ambiguity

Prerequisites: NA

LA362 Creative Writing (The Short Story) (2 Credits)

This course will introduce students to the form, structure, and techniques of short story writing.

The objective is to help students learn how to write clearly and coherently, with reference to a selection of contemporary writers, while also approaching their subject creatively and using their imagination.

Prerequisites: NA

LA701 Econometric Methods (6 Credits)

Review of basic statistics, simple and multivariate linear regression, hypothesis testing and confidence intervals, nonlinear regression functions, estimation problems (multicollinearity, heteroscedasticity, autocorrelation) and solutions, assessing studies based on multiple regression, introductory overview of regression with panel data and timeseries data, regression with limited dependent variables (legit, probit, tobit), causal inference methods (instrumental variables regression, experiments and quasi-experiments)

Prerequisites: NA

LA702 Advanced Positive Psychology (6 Credits)

1. Introduction: Medical model and its differences with the strengths model. Shift from the traditional deficit approach to the strengths approach
2. Historical and philosophical foundations both Western and Eastern.
3. Determinants of well-being- research, implications and areas to explore
4. The study of Strengths: different strength classifications with focus on VIA (three/four strengths in detail)
5. The role of negative in positive psychology: charting the domain of uneasy but necessary emotions and experiences.
6. Issues in Assessment of well-being: Tools and their standardization, methodological constraints, accepted physiological and psychological indicators
7. Prospects, practices and prescriptions for attainment of well-being
8. Criticism and prospects of positive psychology and its practice in clinical, organizational, health, and teaching

Prerequisites: Master level knowledge in Psychology

LA703 Positive Organizational Behaviour (6 Credits)

1. Introduction and brief overview, need and call for Positive Organizational Behaviour Understanding what is positive- traits, states, and processes. Understanding POB and Positive Organizational Scholarship (POS) and their differences.
2. Framework: Psychological Capital and its effects on the workplace
3. Framework: Work engagement and its effects on the workplace
4. Understanding the two major methodological challenges in POB

5. Positive Organizational Psychology in India: Current position of positive organizational psychology in India and identifying the areas which still need to be explored
6. Interventions in the workplace: effects on well-being and performance, current state of positive psychology interventions at the workplace in India, scope of cross cultural interventions for influencing workplace well-being and performance, designing a workplace intervention

Prerequisites: Master level knowledge in Psychology

LA704 Literary Theory (6 Credits)

1. An overview of critical theory: from new criticism, to feminism, postcolonialism, psychoanalysis, structuralism, post-structuralism and reader-response criticism.
2. An introduction to major literary theorists from Aristotle to Bakhtin, Barthes, Benjamin, Kristeva, Said, Derrida, Showalter, Spivak, and Zizek.
3. Individual case studies of critical papers in literary theory.

Prerequisites: NA

LA705 Cultural Studies: Theory and Practice (6 Credits)

Key concepts and debates:

1. Debates on culture - Arnold, Leavis, Thompson, Williams
2. Mass culture; popular culture: Adorno, Hall, Fiske
3. Ideology; hegemony; power - selections from Williams, Althusser, Gramsci, Foucault
4. Representation – Hall

Modern contexts:

1. Globalisation
2. Neoliberalism
3. Social movements shaping questions of identity: gender, class, caste, race, and sexuality

The texts:

1. Media; spaces; subcultures; everyday practices

Prerequisites: MA in English or Cultural Studies

LA706 Development Economics (6 Credit)

Introduction to and overview of development economics Labour: labour supply, labour demand, wage structure, agricultural labour market, labour mobility, labour market discrimination, unemployment, skills, labour unions, labour market

Health: health behaviours, health insurance, health financing, health inequality, physicians, health policy, industrial organization of health (pharmaceutical and hospitals), environment and health, health and public finance

Education: Quality of education, exams and outcomes, returns to education, schooling, teacher quality, public policies to address education production function problems, education financing higher education regulation

Prerequisites: LA 701 Econometric Methods.

LA707 Macroeconomic Theory (6 Credits)

Classical Economics: Employment and output determination, Say's Law, quantity theory of money.

Keynes and Macroeconomics: General Theory, main prupusitious, analysis uf lite labour market, on Say's Law and the quantity theory of money.

Orthodox Keynesian School: TS-1,M model for a closed economy, underemployment equilibrium in the Keynesian model, IS-LM model for an open economy, Phillips curve.

Monetarist school of thought: Quantity theory of money approach, expectationsaugmented Phillips curve, balance of payments theory and exchange rate determination.

New Classical Economics: Rational expectation hypothesis, continuous market clearing, aggregate supply hypothesis, equilibrium business cycle theory, policy implication and Lucas critique
Real Business Cycle school: The transition from monetary to real equilibrium business cycle theory, Supply-side shocks, Real business cycle theory, Technology shocks

New Keynesian Economics: Core propositions and features of new Keynesian economics, Nominnl ri iditics, Real rigidities, New Keynesian business cycle theory

Prerequisites: NA

LA710 Modem Indian Literature: Currents and Countercurrents (6 Credit)

This course will critically engage with the idea of India as reflected in its literature. It will deeply contextualise modem Indian literature with specific reference to questions of:

1. Language
2. Gender
3. History
4. Urbanity

Prerequisites: NA

LA795 Candidacy (0 Credit)

The objective of this candidacy is to evaluate the candidate's ability to carry out research and shall include the evaluation of the knowledge breadth of the student, including the research comprehension.

Prerequisites: Student must have completed the course credit requirement for the program registered for.

LA798 Independent Study (variable Credits)

Students registering for this course are expected to get versed in a particular topic allotted by the course instructor. The topic and the credits are assigned by the course instructor. There will not be any regular lecture delivered for this course type.

Prerequisites: The course is available only to PG students.

LA799 Thesis (variable Credits)

Students registering for this course are associated with a supervisor and have to carry out research work. Student will be evaluated for the program in research at the end of semester.

Prerequisites: Student must have cleared candidacy.

Courses in Chemistry

CY200 Smart Functional Materials (2 Credits)

Introduction to smart “stimuli-responsive” materials with respect to types of materials: single stimuli responsive, dual stimuli responsive and multiple-stimuli responsive materials. Application towards drug delivery, tissue engineering, biomedical sensors and actuators and multi-layer data writing.

Prerequisites: NA

CY201 Electrochemistry and Charge Transfer Dynamics (2 Credits)

Nernst equation, Normal and Formal potential, Redox potentials with sign conventions, Feasibility of a redox titration, redox potential at the equivalence point, redox indicators, high temperature redox reactions. Electrical Double layer formation at electrode surface: Theories of Double-Layer structure at electrode surface, diffuse-double-layer theory of Gouy and Chapman, the Stern Model, Influence of double layer on charge transfer processes. Current-potential relationship (Butler-Volmer and Tafel equations). Factors affecting electron transfer. Energetics at Solid/solid interface and solid/liquid interface, Determination of oxidation state and energetics of surfaces (XPS/UPs studies).

Prerequisites: NA

CY202 Applied Chemistry (2 Credits)

Introduction to Chemical kinetics, Basics in Electrochemistry: Electrochemical Principles and Reactions, Basic concepts of electrochemical cells and batteries, Basic concept of Industrial Chemistry, Laboratory vs Industrial synthesis, Homogeneous and Heterogeneous catalysis.

Prerequisites: NA

CY203 An Introduction to Food Science and Technology (2 Credits)

Introduction: Food in relation to health, Cooking methods; Cereals and Cereal Products; Pulses; Nuts and Oil Seeds; Milk and Milk Products; Eggs: structure and composition etc.; Flesh Foods; Vegetables and fruits: composition and nutritional value; Sugar and related products: structure, artificial sweeteners; Spices; Beverages and Appetites: Coffee, tea, milk and malted beverages etc.; Food Adulteration: types, international adulteration, metallic contamination, food laws; Food Preservation: different methods and chemicals employed for this process; Food Additives, Food Technology etc.

Prerequisites: NA

CY501 Quantum Chemistry (4 Credits)

Revisiting pre-quantum theory. Postulates of quantum mechanics (non-relativistic), Time dependent and time-independent versions of Schrodinger equation, Eigenvalue problem for energy operator. Model problems (the particle-in-a-box, the harmonic oscillator, molecular vibration and normal modes). Hydrogen atom and atomic orbitals, probabilities and electrondensity distribution. Born-Oppenheimer approximation, molecular orbitals from valence bond and molecular orbital theory and Linear Combination of Atomic Orbitals. Introduction to basis-set (Slater and Gaussian-type orbitals). Hartree-Fock Self-Consistent

Field (SCF) Theory, electron correlation and variational principle; electron spin. Brief introduction to relativistic quantum chemistry.

Prerequisites: NA

CY502 Chemical Kinetics and Surface Science (4 Credits)

Diffusion, Thermal conductivity, Viscosity, Effusion, Drift velocity, Nernst-Einstein equation, Stokes-Einstein equation Complex reactions, Chain reactions (free radical reaction, polymerization kinetics), Enzyme reaction, Inhibition kinetics, Temperature dependence of reaction rate: Linear and non-linear Arrhenius equation, Interpretation of Arrhenius parameters Various theories of unimolecular reactions, Potential energy surfaces for bimolecular reactions, Adiabatic and non-adiabatic curve crossing processes, Collision theory. Transition state theory, Activation/thermodynamic parameters, Erying equation Kinetics in the excited state: Jablonski diagram, Kinetics of Unimolecular and bimolecular photophysical and photochemical processes, Quantum yield calculation, Excited state lifetime-quenching constant, Resonance energy transfer rates (RET), Rate and efficiency of RET, Dynamics of electron transfer, Solvent reorganization energy, Marcus theory of electron transfer. Importance of interfaces, adsorption isotherms, surface charge and zeta potentials, surface tension, characterization methods (SEM, TEM, XPS, UPS), surface catalytic reactions.

Prerequisites: NA

CY503 Coordination Chemistry (6 Credits)

Transition Metal Chemistry: Structure, bonding, and properties of transition metal ligand complexes - geometry, coordination number, isomerism, thermodynamic stability, chelate and macrocyclic effect, VBT, CFT and their limitations: d-orbital splitting, Term Symbols, microstates, R-S coupling, CFSE for d0 to d10 systems, pairing energy, low spin and high spin complexes and magnetic properties, J-T distortion, selection rules of electronic transition: Laporte Forbidden Rule, Spin Selection Rule Charge Transfer Spectra (CT), Ligand to Metal Charge Transfer (LMCT), Metal to Ligand Charge Transfer (MLCT), Ligand to Ligand Charge Transfer (LLCT), molecular orbital (MO) theory of small molecules.

Inorganic Reaction Mechanism: Substitution in Oh and Square Planner complexes, thermodynamics and kinetics, stability of complexes, lability, trans-effect, conjugate base mechanism, mechanism of redox reactions, racemization, electron transfer reaction: inner sphere and outer sphere mechanism, Marcus theory, photosubstitution and photo redox reactions of Cr, Co, and Ru compounds.

Prerequisites: NA

CY504 Chemistry of Main Group Elements (6 Credits)

Theories of bonding, acids and bases, thermodynamic acidity parameters; hydrogen and classical hydrogen bond, water, hydrates, hydrogen ions, metal hydrides, activation of hydrogen complexes; alkali metals in liquid ammonia; boron, boranes, carboranes, borazines and borates; allotropy of carbon; silane and polysilanes, silicone Polymers, silicates; compounds of nitrogen, activation of nitrogen, nitrogen fixation, hydrogen, halogen, oxygen and nitrogen compounds of phosphorous; oxygen and singlet oxygen, ozone, complexes of molecular oxygen; N-S compounds; sulphides, oxides and oxoacids of sulphur, chalcogenides and polychalcogenides; halogens, polyhalides, interhalogen compounds, charge-transfer

complexes of Halogens; Compounds of Xenon and other noble gases; Zintl compounds and homometallic clusters.

Prerequisites: NA

CY505 Organic Reactions and Reagents (6 Credits)

A brief introduction to substitution, elimination, addition, oxidation, reduction, rearrangement and pericyclic reactions. Functional group transformations: alcohols to alkylating agents, Mitsunobu and related reactions, introduction of functional groups by nucleophilic substitution at saturated carbon, nucleophilic cleavage of C-O bonds in ethers and esters and inter-conversion of carboxylic acid derivatives. Oxidation: Metal based oxidizing reagents: A review and detailed discussion of chromium, manganese, ruthenium, silver and other metal based reagents. Non-metal based oxidizing reagents: DMSO, peroxide, peracid and oxygen based oxidation. Miscellaneous oxidizing reagents like IBX, DMP, CAN, DDQ, periodate etc. Reduction: Homogeneous and heterogeneous; Discussion on borane based racemic and chiral reagents, hydrogenations aluminium, tin, silicon based reducing agents. Dissolving metal reductions. Selectivity and protecting groups: Illustration of chemoselectivity, regioselectivity and stereoselectivity with examples; protecting groups for alcohols, amines, acids, ketones and aldehydes.Cycloaddition reactions:Diels-Alder reaction; general features, dienes, dienophiles, selectivity, intramolecular and intermolecular reactions, hetero-Diels Alder reaction. 1,3-dipolar cycloaddition reactions; general features, dipoles, dipolarophiles. [2+2] cycloaddition reactions; general features, selected examples.Molecular rearrangements:Illustration of electron deficient and electron rich skeletal rearrangements with examples; Sigmatropic rearrangements-Claisen and related rearrangements, Cope and oxy-Cope rearrangements; 2,3-sigmatropic rearrangements and ene reaction.

Prerequisites: NA

CY506 Inorganic Chemistry Practical (2 Credits)

1) Synthesis inorganic and coordination compounds.

2) Catalytic reaction and techniques.

3) Purification and separation techniques.

4) Characterization through analytical techniques.

5) Qualitative determination of compounds, molecules and elements.

6) Quantitative estimation of compounds, molecules and elements.

Prerequisites: NA

CY507 Statistical Mechanics and Thermodynamics (4 Credits)

Concept of ensembles, partition functions and distributions, microcanonical, canonical and grand canonical ensembles, canonical and grand canonical partition functions, Boltzmann, Fermi-Dirac and Bose-Einstein distributions. Canonical partition function in terms of molecular partition function of non-interacting particles, Translational, rotational and vibrational partition functions.

Temperature dependence of the second virial coefficient. Thermodynamics of solids - Einstein and Debye models. T3 dependence of heat capacity of solids at low temperatures.

Fermi function, Fermi energy, free electron model and density of states, chemical potential of conduction electrons.

Prerequisites: NA

CY508 Molecular Spectroscopy (4 Credits)

The rigid diatomic rotor, energy eigenvalues and eigenstates, selection rules, intensity of rotational transitions, the role of rotational level degeneracy, the role of nuclear spin in determining allowed rotational energy levels. Classification of polyatomic rotors and the non-rigid rotor. Vibrational spectroscopy, harmonic and anharmonic oscillators, Morse potential, mechanical and electrical anharmonicity, selection rules. The determination of anharmoncity constant and equilibrium vibrational frequency from fundamental and overtones. Normal modes of vibration, G and F matrices, internal and symmetry coordinates. Electronic transitions, Franck-Condon principle. Vertical transitions. Selection rules, parity, symmetry and spin selection rules. Polarization of transitions. Fluorescence and phosphorescence. Raman spectroscopy, polarizability and selection rules for rotation and vibrational Raman spectra.

Prerequisites: NA

CY509 Bioinorganic Chemistry (6 Credits)

Metal ions in biology: their occurrence and function, active-site structure and function of metalloproteins and metalloenzymes with various transition metal ions and ligand systems; oxygen binding properties of heme and non-heme proteins, their coordination geometry and electronic structure, co-operativity effect, Hill coefficient and Bohr Effect; characterization of O bound species by Raman and infrared spectroscopic methods; representative synthetic models of heme and non-heme systems. Electron transfer proteins - active site structure and functions of ferredoxin, rubridoxin and cytochromes, and their comparisons. Vitamin B12 and cytochrome P450 and their mechanisms of action. Metals in medicine: therapeutic applications of cis-platin, radio-isotopes (e.g., Tc & I) and MRI agents. Toxicity of metals: Cd, Hg and Cr toxic effects with specific examples.

Prerequisites: NA

CY510 Stereochemistry and Reaction Mechanism (6 Credits)

Stereochemistry: Introduction to molecular symmetry and point groups. Topicity and prostereoisomerism, nomenclature of stereotopic ligands and faces, stereoheterotopic ligands and NMR spectroscopy. Centre of chirality, assignment of absolute stereochemistry, CIP rules, axial chirality, planar chirality and helicity, descriptors for absolute stereochemistry. Conformational analysis: acyclic systems, cyclic systems,cyclohexane and decalins, conformation and reactivity with examples from molecular rearrangements, neighbouring group participation, elimination reactions, formation and cleavage of epoxides, quantitative correlation between conformation and reactivity, Winstein-Eliel equation, Curtin-Hammett principle.

Stereoselectivity: Classification, terminology, principle of stereoselectivity, examples of diastereoselectivity and enantioselectivity including few examples from pericyclic reactions. Circular dichroism, ORD, cotton effect, application of ORD and CD in steriods, examples illustrating the usefulness of Cotton effect.

Reaction mechanisms: Definition of reaction mechanism, transition state theory, kinetics, qualitative picture. Substituent effects, linear free energy relationships, Hammett equation and related modifications. Basic mechanistic concepts like kinetic vs thermodynamic control, Hammond postulate, Curtin-Hammett principle, isotope effects, general and specific acid-base catalysis, and nucleophilic catalysis.

Nucleophilic substitution, various types, stability and reactivity of carbocations, nucleophilicity and basicity, neighbouring group participation and rearrangements, steric effects in substitution reactions, classical and non-classical carbocations.

Rearrangements: neighboring group participation, ring expansion, carbocation, pinacol, dienone-phenol, benzilic, Favorskii, Baeyer-Villiger and Beckmann rearrangements.

Prerequisites: NA

CY511 Physical Organic Chemistry (2 Credits)

Symmetry-adapted orbitals. Mixing rules and buildup approach to molecules and molecular complexes. Energy surface for bond breaking and making. Kinetic vs thermodynamic control, Curtin-Hammett principle, Hammond Postulate Reactive intermediates: Carbocations, carbanions, carbenes, benzyne. Empirical scales for electronic, steric, and solvent effects. Mechanism according to free-energy correlation and correspondence with theory of orbital interaction. Illustrative examples. Linear free energy relationship, Hammett and Taft equations.

Prerequisites: NA

CY512 Organic Photochemistry (2 Credits)

Photochemistry: Basics principles of organic photochemistry - Reactivity of simple chromophores - photochemistry of carbon cantered radicals.

Photochemistry of Alkenes: Excited States of alkenes - photochemistry of alkene - geometrical isomerisation - photosensitised geometrical isomerisation – photocycloaddition reactions of alkene - di-pi-methane rearrangement - electron transfer mediated reactions of alkene.

Photochemistry of carbonyl compounds: Norrish type I and type II reactions - photochemical cycloadditions - photochemistry of aromatic systems - electron transfer and nucleophile.

Prerequisites: NA

CY513 Physical Chemistry Lab (2 Credits)

Study of charge transfer complexes using colorimetric method, Study of fluorescence quenching, Phase behaviour studies, reaction kinetics study (spectroscopic and polarometric), Study of intermolecular hydrogen bonding, Denaturation Studies of biomolecules, Programming and electronic structure calculations.

Prerequisites: NA

CY514 Organic Chemistry Lab (2 Credits)

Separation of a binary mixture of organic compounds, synthesis and structural characterization of biologically relevant organic compounds, extraction and purifications of

bio-sourced organic compounds, target oriented synthesis of macromolecules for emerging applications, templated synthesis and photo-physical characterization of nanomaterials for diverse applications.

Prerequisites: NA

CY515 Computations in Chemistry (2 Credits)

Computational Methods: Time-independent perturbation theory, degenerate states, Hellmann-Feynman theorem, Term symbols for atoms, Conjugated pi-systems and Huckel theory, frontier orbital theory, Electronic structure calculations of simple systems.

Group theory: Concept of group, Symmetry operations and symmetry elements in molecules, Matrix representations of symmetry operations, Point groups, Irreducible.

representations and character tables, Great orthogonality theorem and its proof. Application of group theory to atomic orbitals in ligand fields, molecular orbitals, hybridization.

Prerequisites: CY501 or, equivalent

CY516 Mathematics for Chemists (4 Credits)

Logarithm - Vectors - Probability and Statistics - Regression and Correlation - Matrix and determinant - Differentiation and integration

Prerequisites: NA

CY517 Basics of Molecular Biology (4 Credits)

Cell theory and cell as the basic unit of life; Structure of prokaryotic and eukaryotic cell; Plant cell and animal cell.

Chemical constituents of living cells: Biomolecules-structure and function of proteins, carbohydrates, lipids, nucleic acids; Enzymes-types, properties, enzyme action.

Photosynthesis: Photochemical and biosynthetic phases of photosynthesis; Cyclic and non cyclic photophosphorylation; Chemiosmotic hypothesis; Photorespiration; C3 and C4 pathways;

Respiration: Exchange of gases; Cellular respiration - glycolysis, fermentation (anaerobic), TCA cycle and electron transport system (aerobic); Energy relationsNumber of ATP molecules generated; Amphibolic pathways.

Principles and process of Biotechnology: Genetic engineering (Recombinant DNA technology). Application of Biotechnology in health and agriculture:Genetically modified organisms.

Prerequisites: NA

CY600 Physical Methods for Structure Determination (6 Credits)

Introduction to a wide range of experimental methods for structure determination including X-ray diffraction; Electron emission spectroscopies; Spectrophotometry, Laser based Methods, X-ray Photo electron spectroscopy (XPS), Thermal property analysis; Chromatographic techniques, mass spectroscopy, surface area analysis, permeability analysis; mechanical testing; Electron microscopy

Prerequisites: NA

CY601 Principles of Photochemistry and Molecular Spectroscopy (6 Credits)

Molecular orbital theory, Frank-Condon principle and vibrational structure of electronic spectra. Fluorescence and phosphorescence, Solvent effect on emission, Rotational spectroscopy, vibrational spectroscopy, Raman Effect.

Prerequisites: NA

CY602 Macromolecular Chemistry (6 Credits)

Introduction to macromolecular science with respect to types of polymers and their nomenclature; polymer synthesis copolymers and ionomers; polymer structure and morphology; physical properties of polymers; network formation/gelation of macromolecules; post-polymerization modification. Functional Organic Materials.

Prerequisites: NA

CY603 Organometallic Chemistry: Principles and Applications (6 Credits)

Definition, the first few organometallic complexes, thermodynamics and kinetics of organometallic compounds, the 18-electron rule. Different types organometallic bonding: Metal- alkyls, aryls, hydrides, organometallic bonding with multiple bonds, complexes of pi-bound ligands such as carbonyls, phosphine complexes, MO theory of organometallic complexes, isolobal analogy. Fundamental reaction process: oxidative addition and reductive elimination; insertion and elimination; ligand substitution processes, transmetallation, nucleophilic and electrophilic addition and abstraction. Preparative and characterization methods: general methods for the preparation of organometallic compounds and spectroscopic and analytical techniques for the elucidation of structure, properties and reactivates. Synthetic Applications: Coupling reactions, cyclization reactions, addition reactions, carbonylation, Pauson-Khand reaction, olefin oxidation, carbenes and activation reactions, hydrogenation, hydroformylation, isomerization, metathesis and polymerization reactions. CO2 activation, C-H activation, C-C activation, click catalysis, oxidation reaction.

Prerequisites: NA

CY604 Solid State Chemistry (4 Credits)

Crystal structure of solids; preparative methods; Braggs diffraction law and its limitations; crystal structure determination; phase diagram and phase transitions; optical; electrical and magnetic properties; conductivity; Nanostructured materials; organic solid state materials, conjugated polymers, fullerenes, carbon nanotubes and graphene.

Prerequisites: NA

CY605 Advanced Organic Chemistry (6 Credits)

Retrosynthetic Analysis: Basic principles and terminology of retrosynthesis, Linear and convergent synthesis. Important strategies of retrosynthesis, functional group transposition, important functional group interconversions Protecting groups: Protection and deprotection of hydroxy, carboxyl, carbonyl, carboxy amino groups and carbon-carbon multiple bonds; chemo- and regioselective protection and deprotection; illustration of protection and deprotection in synthesis.

Selectivity in organic synthesis: chemo-, regio-, stereo- and enantioselectivity. Target-oriented synthesis: Designing organic synthesis, Asymmetric Synthesis: Use of chiral catalysts, organocatalysis, chiron approach and N-heterocyclic carbenes. Principles and use of

enzymes in the syntheis of industrially important sugar/fatty acid esters, sugar nucleotide derivatives; enantiomeric pure compounds and biobased platform chemicals.

Methodolgies for the construction of 3-7 membered rings, medium and large rings. Application in natural product synthesis. Methodologies for the construction of 3-7 membered heterocyclic rings. Application In organic synthesis.

Prerequisites: NA

CY606 Advanced Inorganic Chemistry (6 Credits)

Bio-inorganic Chemistry: metal ions in biology, their occurrence and function, Hill coefficient and Bohr Effect; characterization of O-bound species by Raman and infrared spectroscopic methods; representative synthetic models of heme and non-heme systems. Electron transfer proteins - active site structure and functions. Vitamin B_{12} and cytochrome P_{450} and their mechanisms of action. Metals in medicine; Inorganic Reaction Mechanism.

Prerequisites: NA

CY607 Interpretative Molecular Spectroscopy (6 Credits)

Mass spectrometry, the production and analysis of positive ions, molecular ions, application of isotopic abundance measurements, fragmentation modes and rearrangement of ions. Mass spectra of certain chemical classes. Electronic spectroscopy (UV-visible,fluorescence and phosphorescence):Simple chromophoric groups, conjugated and aromatic systems. Characteristic absorption of organic and inorganic compounds. Infrared spectroscopy: .Characteristic group frequencies of organic and inorganic molecules. Nuclear magnetic resonance spectroscopy of compounds containing 1H,13C,19F and 31P nuclei. Identification of organic and inorganic compounds using combination of spectral data.

Prerequisites: NA

CY608 Nanostructured Materials (2 Credits)

Concept of colloids, electrical properties of colloids, zeta potential, stabilization of nanomaterials, DLVO theory, Schultz-Hurdy Rule. Adsorption on nanoparticle surface, BET

adsorption isotherm (Principle). Surface functionalization of nanoparticles (Overview), grafting to and grafting from concept, Application in subsurface engineering, drug delivery systems, semiconductor work function modulation through controlled surface functionalization.

Prerequisites: NA

CY609 Chemistry of Materials (6 Credits)

Molecular orbital description, Valence bond, molecular orbital theory, ionic bonds, dipole moment, resonance, delocalization, aromatic molecules and solids. Conjugated systems and synthetic methods. Fluorescence and phosphorescence. Electromagnetic spectrum; quantum yield (QY); reasons for QY<1 and QY>1; concept of 1 Einstein; Jablonski diagram; Fluorescence quenching and mechanism.

Introduction to macromolecular science; polymer synthesis; molecular weight determination; copolymers and ionomers; polymer structure and morphology; physical properties of polymers; Functional Organic Materials.

Definition of organometallic complexes, the first few organometallic complexes, thermodynamics and kinetics of organometallic compounds, the 18-electron rule. Different types organometallic bonding: Metal- alkyls, aryls, hydrides, organometallic bonding with multiple bonds, complexes of pi-bound ligands such as carbonyls, phosphine complexes, MO theory of organometallic complexes, application in industrially relevant process.

Prerequisites: NA

CY610 Molecular Physical Chemistry for Engineers (2 Credits)

Brief review of elementary thermodynamics and applications, laws of thermodynamics,

Gibbs free energy function, chemical application for Gibbs free energy.

Basic quantum chemistry, particle in the box, application of quantum theory, Schrodinqer equation, particle in a box, application of quantum theory to the energetics of electrons, atoms and molecules.

The kinetics of gases, Chemical kinetics, rates of chemical reactions in gases and surfaces.

Light-matter interactions and molecular spectroscopy, UV-Vis, IR, fluorescence and

Raman spectroscopy.

Prerequisites: NA

CY611 Energy Storage Materials - A brief overview (4 Credits)

1. Induction to various basic energy storage technologies.
2. Verity of batteries and its technology
    I. Nonchargeable and rechargeable batteries
    II. Lead-Acid batteries
    III. Metal and metal-Ion batteries
3. Supercapacitors and its working principle.

Prerequisites: NA

CY612 Molecules in Electric Field (2 Credits)

Introduction to response of materials in presence of electric field, polarizability and hyperpolarizabilities, perturbation theory, linear response theory, calculations of polarizability and first and second hyperpolarizabilities of different molecules using Gaussian software.
Aim of this course is to provide the students an idea of how electronic systems behave under an externally applied electric field and how to calculate the response of the molecules in such fields.

Prerequisites: NA

CY613 Materials for Emerging Applications (2 Credits)

Introduction to physical principles responsible for the properties of important functional materials, with emphasis on the design of material properties for current device technologies as well as emerging and potential engineering applications. Applications of

these functional stimuli-responsive materials in 3D printing, actuation, self-cleaning glass, smart building and energy storage technology.

Prerequisites: NA

CY614 Biomaterials Science and Engineering (2 Credits)

Introduction to Biomaterials, Background history, Properties (Mechanical and Physico-chemical), Resorbability, biodegradation, Biofilm, Material characterization - Analytical instruments, Biological responses, compatibility, cytotoxicity, Proteins, Tissue and blood Response Cell-biomaterial interaction, Animal trials (in vivo models), Metals• types, classifications, applications, Polymers-types, classifications, applications, Biopolymers, Hydrogels, Drug delivery systems/encapsulation, Biomaterials for cardiovascular/pulmonary/ophthalmological applications, Biomaterials for cancer.

Prerequisites: NA

CY615 Power of Computation in Chemistry (2 Credits)

Introduction to quantum chemical approximations used in theoretical chemistry, geometry optimization, study of energetics of chemical reaction, computation of various spectra.

Prerequisites: Basic quantum mechanics, familiar with computers (Linux environment)

CY616 Molecular Geometry Predictions (2 Credits)

The meaning of geometry optimization, basis set, introduction to some useful QM methods (mainly HF and OFT) used for geometry optimization and implementation of geometry optimization techniques (GDIIS, Conjugate, Gradient, Quasi-Newton-Raphson) with those QM methods. Introduction to Gaussian and GaussView software.

Prerequisites: Basic Quantum Mechanics

CY617 Introduction to Solar Energy Materials (2 Credits)

Light harvesting materials, band-gap engineering in oxide/halide based semiconductors, metal-semiconductor junction. Conjugated polymer based systems and their synthesis and properties. DSSC and perovskite based systems and their light driven multifunctional application. Introduction to energy storage systems.

Prerequisites: NA

CY618 Bionanotechnology (2 Credits)

Introduction to nanomaterials and bionanomaterials, nucleic acid nanotechnology and applications; synthesis and biofunctionalization of nanoparticles; RNA interference for gene knockdown; CRISPR-Cas9 for genomic engineering; protein nanotechnology, and design methods; amyloids, antibodies and their applications; biosensors; electrochemical biosensors; nanopore technology, artificial organelles, and cells.

Prerequisites: NA

CY619 Industrial Inorganic Chemistry (2 Credits)

1. Importance of chemical industry.
2. Industrial materials for environmental, renewable energy and energy storage applications.
3. Importance of primary inorganic materials, commodity chemicals.
4. Mineral fertilizers, metals and their compounds.
5. Conversion methodologies of raw materials into industrial products.
6. Metallic-lithium, sodium and its compounds.
7. Inorganic pigments, Ti02, lithopone, ZnS, ZnO and Fe203, luminescent pigments.

Prerequisites: NA

CY620 Photocatalysis in Organic Chemistry (2 Credits)

Basic principles of photocatalysis; Visible-light photocatalysis, photoredox catalysis, Dual photocatalysis; organo-photocatalysis; photocatalysis in synthetic methods; applications of photocatalysis in total synthesis and pharmaceutical ingredients.

Prerequisites: NA

CY622 Introduction to Molecular Modeling (2 Credits)

Basics of molecular modeling. Representation and visualization of molecules. Concept of target and lead identification and steps involved in drug discovery. Protein Data Bank {PDB). Modeling methods: Molecular docking, protein structure prediction methods, similarity search of ligands, quantitative structure-activity relationships (QSAR), pharmacophore modeling, physiochemical properties of compounds.

Working with modeling tools: Protein modeling using Modeller, SWISS-MODEL and Phyre 2, its validation using Ramachandran plot, and visualization using Maestro, PyMol and Swiss-PDB viewers. Protein and ligand preparation and molecular docking using Autodock.

Prerequisites: NA

CY623 The Chemistry of Life (6 Credits)

Introduction to cells, chemistry of cells and bioenergetics, Proteins, DNA, chromosomes and genomes, DNA replication, repair and recombination, DNA replication, analyzing cells, molecules and systems, visualizing cells, membrane structure, transport of small molecules and electrical properties of membranes, intercellular compartment and protein sorting, Intracellular membrane traffic, energy conversion-mitochondria and chloroplasts, cell signalling, cytoskeletons, cell cycle, cell death, extracellular matrix, cancer, development of multicellular organism, stem cells and tissue renewal, pathogen and infection, the innate and adaptive immune systems.

Prerequisites: NA

CY624 Chemistry of Heterocyclic Compounds and Natural Products (6 Credits)

Heterocyclic Compounds: Introduction to heterocyclic compounds, importance of heterocycles in medicine and materials, systematic nomenclature of heterocyclic compounds. Preparation, reactions and chemical properties of three membered heterocyclic compounds with one and

two hetero atom, four membered heterocyclic compounds with one hetero atom. Structure, synthesis and reactivity of five and six membered heterocyclic compounds. Aromatic heterocyclic compounds: Pyrrole, furan, thiophene, pyridine, quinoline, isoquinoline, indole, etc. Named reactions of heterocyclic compound synthesis such as Fiest Benary furan synthesis, Knorr and Paal-Knorr pyrrole synthesis, Barton-Zard reaction, Robinson-Gabriel synthesis, Hofmann-Loffler-Freytag reaction, Hantzsch pyridine synthesis, Biginelli and Chichibabin reations. Natural Products: role of natural products in drug discovery, structure and chemical properties of alkaloids, terpinoids, and steroids. Physicocemical properties of amino acids, chemical synthesis of peptides, properties of mono- and di-saccharides.

Prerequisites: NA

CY625 Cheminformatics and Rational Drug Design (6 Credit)

1. Introduction.
2. Structure of macromolecules.
3. Computational representation of chemical information.
    a. SMILES - Simplified Molecular Input Line Entry Specification.
    b. InChi - IUPAC International Chemical Identifier.
    c. 20 and 30 Molecular Structures.
    d. Other representations.
4. File formats (Plain sequence format, FASTA, GenBank flat file format, EMBL, NBRF/PIR, Swiss-Prat, PDB).
5. Molecular descriptors.
6. Molecular similarity.
7. Chemical databases.
    a. Searching Chemicals using online resources.
    b. Applications.
8. Biological databases.
    a. Nucleotide and protein databases.
    b. Pathway databases.
    c. Literature databases.
    d. Searching Web-based Biological Databases.
    e. Sequence Analysis and comparison.
    f. Patterns, Motifs, Profiles and Domains.
9. Data mining.
10. Molecular drawing and interactive visualization.
11. Computer-aided drug design (CADD) techniques.
12. Virtual Screening.
13. Drug-target interactions.
14. Combinatorial library design.
15. ADME properties, drug-likeness and druggability.
16. Molecular dynamics simulation.
17. Hands on exercises.

Prerequisites: NA

CY626 Advanced Molecular Simulation - Theory and Practice (6 Credit)

Introduction to programming: General introduction to algorithm, flowchart, and programming, introduction to syntax and hand-on exercises.

Density functional theory (OFT): Fermi and Coulomb holes - Different exchange-correlation.

functionals - Kohn-Sham approach - Coding OFT - Hands-on exercise (Using Gaussian and

Gauss View software).

Classical Molecular dynamics (MD): Purpose of classical MD, Different interactions and force field, basic classical MD algorithm - Hands-on exercises.

Genetic Algorithm (GA): basic principle: Selection, Crossover, Mutation, Fitness; potential energy, function, application to atomic cluster.

Prerequisites: NA

CY627 An Introduction to Catalyst Design: Function and Application (2 Credit)

Concepts in Catalyst: Design, Homogeneous Catalyst, Heterogeneous Catalyst, Metal Based Catalyst, Organo-Catalyst, Bio-Catalyst, Solid-Acid/Base Catalyst, Dual-Function Catalyst; Frustrated Lewis Pair (FLP), Engineering a Catalyst; Preparative Protocol, Characterization Techniques. Catalyst Function: Selected Examples of Industrially Important Catalytic Processes, Oxidation, Reduction, FLP Catalysis, Hydrocarbon Activation, Asymmetric Catalysis; Catalyst Poisoning, Transition State Model, Surface Phenomenon.

Prerequisites: NA

CY628 Nano-engineered Molecular Materials (6 Credit)

Introduction to nano-engineered molecular materials; design, tailoring, and combination of chemical building blocks as carriers of desired physico - chemical properties to make such materials; structure-property relationships; application of such materials in automobile industry, aerospace and aeronautics, building/construction industry, consumer electronics, fuel cell, batteries, sensors, actuators, pharmaceutical industry and biomedical applications.

Prerequisites: NA

CY629 Introduction to Health, Safety and Environmental Practices (2 Credit)

Concepts of HSE, Introduction to occupational safety and health (OHS), OHS regulations and law in India, technical standards, codes and guidelines on OHS, national and international standards of personal protective equipment and fire protection, health and safety at work place, hazards and risk assessments, waste management, fire protection and prevention, principles of chemical safety, radiation safety and bio safety, emergency preparedness, environment management and pollution control.

Prerequisites: NA

CY699 Thesis (variable Credits)

Students registering for this course are associated with a supervisor and have to carry out research work. Student will be evaluated for the program in research at the end of semester.

Prerequisites: NA

CY795 Candidacy (0 Credit)

The objective of this candidacy is to evaluate the candidate's ability to carry out research and shall include the evaluation of the knowledge breadth of the student, including the research comprehension.

Prerequisites: Student must have completed the course credit requirement for the program registered for.

CY798 Independent Study (variable Credits)

Students registering for this course are expected to get versed in a particular topic allotted by the course instructor. The topic and the credits are assigned by the course instructor. There will not be any regular lecture delivered for this course type.

Prerequisites: The course is available only to PG students.

CY799 Thesis (variable Credits)

Students registering for this course are associated with a supervisor and have to carry out research work. Student will be evaluated for the program in research at the end of semester.

Prerequisites: Student must have cleared candidacy.

Courses in Computer Science and Engineering

CS100 Software Tools & Technologies I (4 Credits)

Scripting Languages (shell programming, python, Java Script), Web programming, GUI programming tools, Document Processing tools.

Prerequisites: NA

CS101 Discrete Structures I (4 Credits)

Sets, relations, functions, Notion of proof: proof by counter-example, the contrapositive, proof by contradiction, inductive proofs. Combinatorics: Basic counting techniques, pigeon-hole principle, recurrence relations, generating functions, Polya's counting theorem. Introduction to probabilistic method in combinatorics, Inclusion-exclusion principle, Introduction to number theory and group theory.

Prerequisites: NA

CS102 Data Structures (4 Credits)

Stacks, Queues, Lists; Sorting and Searching; Trees, Tree Traversals, Heaps; Binary Search, Binary Search Trees; Graphs: Representations, Depth First Search, Breadth First Search.

Prerequisites: NA

CS200 Software Tools & Technologies Lab II (4 Credits)

Software Management tools, CVS, lab exercise for developing large system and application programs.

Prerequisites: NA

CS201 Discrete Structures II (2 Credits)

Basics of graph theory, Formal logic: Propositional logic: proof system, semantics, completeness, compactness.

Prerequisites: NA

CS202 Algorithms I (4 Credits)

Algorithm analysis; worst and average case; Recurrences and asymptotes; Algorithms for sorting and selection; Randomized techniques; Search structures: heaps, balanced trees, skip lists, hash tables; Dynamic programming and greedy algorithms; Graph algorithms: breadth- and depth-first search, MSTs, shortest paths; NP-Complete problems.

Prerequisites: NA

CS203 Theory of Computation I (4 Credits)

Alphabets, languages, finite state machines - deterministic and non-deterministic finite automata. Context Free Grammars, Context Free Languages, Parse trees, Push Down

Automata, Pumping lemma for CFLs and applications, CYK algorithm Turing machines, Variants, Undecidability theory.

Prerequisites: NA

CS204 Computer Organization & Architecture (4 Credits)

Introduction, Overview of basic digital building blocks; truth tables; basic structure of a digital computer, Number representation, Assembly language programming for some processor, Basic building blocks for the ALU, Adder, Subtractor, Shifter, Multiplication and division circuits, Control path microprogramming (only the idea), hardwired, logic; External interface, Memory organization; Technology-ROM, RAM, EPROM, Flash etc. Cache; Cache coherence protocol for uniprocessor (simple), I/O Subblock, I/O techniques -interrupts, polling, DMA.

Prerequisites: NA

CS250 Operating Systems (4 Credits)

Introduction, System Calls; Processes and Threads Concepts; CPU Scheduling, Process Synchronization; Classical Problems (Producer Consumer, dining philosophers etc.); Deadlocks: Detection, Prevention and avoidance mechanisms. Memory Management, Segmentation& Paging Demand Paging; Files and Directories organization, Security and Protection Mechanisms; System Threats, Case studies: UNIX and NT.

Prerequisites: NA

CS251 Introduction to Language Processing (4 Credits)

Compiler structure: analysis-synthesis model of compilation, various phases of a compiler, tool based approach to compiler construction. Lexical analysis,Syntax analysis, Syntax directed translation, Type checking, Run time system, Intermediate code generation,Code generation.

Prerequisites: NA

CS252 Algorithms II (4 Credits)

Reviewing sorting and graph algorithms, Linear programming; Network flow algorithms; NP-completeness; Approximation algorithms; Randomized algorithms; Geometric Algorithms.

Prerequisites: NA

CS253 Theory of Computation II (2 Credits)

Reviewing concepts of Turing Machines. Time and Space bounded computation. Reductions, theory of NP completeness, Introduction to time and space complexity.

Prerequisites: NA

CS254 Database Management Systems (4 Credits)

Overview of file organisation techniques: sequential, direct, indexed, hashed, inverted, B-trees, Data models: relational, network, hierarchical, NoSql, Relational model: algebra, calculus, normal forms. Implementation of query languages, security and protection of data

recovery methods, Concurrent operations on data bases, introduction to distributed data base systems.

Prerequisites: NA

CS300 Principles of Programming Languages (6 Credits)

Brief history of development of programming languages, Introduction - imperative programming, functional programming, logic programming and object oriented programming, Values and types, Notion of variables, Lifetime of variables: local, global and heap variables, Bindings and environments, bindables, scopeblock structure, static and dynamic scoping, Abstraction - procedural and function abstractions, Type systems - monomorphic type systems. Introduction to polymorphism, Types of polymorphism - overloading, parametric polymorphism, polymorphic types, Type checking and type inference – inference rules for monomorphic types, introduction to polymorphic type inference, Functional programming, Logic Programming, Object oriented programming.

Prerequisites: NA

CS301 Computer Networks (6 Credits)

Layer approach, Packet switching techniques, Performance metrics; Applications: FTP, SSH, DNS, WWW; Transport Layer: TCP flow control, error control, congestion control, congestion control, UDP; Network Layer: Internetworking, Tunneling, Encapsulation, Fragmentation, IP, Routing and the related protocols, ICMP, ARP, RARP, DHCP, IPv6, RIP, OSPF; Advanced Internetworking, Multicast routing, Queuing disciplines and buffer management techniques; Data link layer: framing, medium access mechanism; Network security: Public key and private key cryptography, digital signature, firewalls; Advanced topics: SDN and Open flow Architectures.

Prerequisites: NA

CS499 Thesis (Variable Credits)

Students registering for this course are associated with a supervisor and have to carry out research work. Student will be evaluated for the program in research at the end of semester.

Prerequisites: This course is only for BTech Honours student.

CS500 Science of Computation (TOC/DS/Algorithms) (3 Credits)

Reviewing concept of mathematical proof, sets, relations, bijection, Basic combinatorics and pigeon-hole principle, Elementary concepts in Graph Theory

Formal languages and various computational models: Finite Automaton, Push Down Automaton and Turing Machines. Halting Problem and Undecidability. P, NP, NP-Hard, NP-Complete classes

Methods for analysis of algorithms. Sorting and searching, Algorithm Paradigms: Greedy, Divide-Conquer, Dynamic Programming. Graph algorithms: breadth- and depth-first search, MSTs, shortest paths.

Prerequisites: NA

CS501 Computer Systems (OS, Architecture, Compilers, DBMS) (3 Credits)

Basic concepts of operating systems, architecture, compilers, and data base management systems.

Prerequisites: NA

CS502 Graph Theory and Applications (6 Credits)

Introduction to graphs, diagraphs, Paths, Cycles, connectivity, Euler tours, Hamiltonian paths and cycles, isomorphism, cut vertices, cut edges, contractions, minors, minimum spanning tree.

Graph Classes: trees, bipartite graphs, planar graphs, and other special classes of graphs.

Coloring of graphs: Vertex coloring, edge coloring and other coloring problems.

Matchings: Perfect matchings, Hall's theorem, Tutte's theorem, Konig's theorem.

Petersen's theorem.

Prerequisites: NA

CS503 Lightweight Cryptography (6 Credits)

The Why and What of Lightweight Cryptography (LWC). Quantifying Lightweightness: Hardware/Software Perspectives. Lightweight block ciphers, hash functions, public key cryptography. Trends in lightweight design for non-linear/linear operations. The impact of MILP, SAT and SMT Solvers in LWC. Familiarization with tools: Sage, Gurobi, Z3. Design strategies for (lightweight) cryptographic hardware: ASIC/FPGA design flows. Familiarization with tools: LeonardoSpectrum, ModelSim. Understanding trade-offs in resource efficient cryptography. Advanced cryptanalytic strategies. Standardization efforts in LWC.

Prerequisites: CS553

CS505 Big Data Analytics (6 Credits)

Introduction: What is Big Data. Major tools used by data scientists, Data Analytics Fundamentals, Selected Topics of Distributed Systems, Hadoop Fundamentals I, Hadoop Fundamentals II (HDFS, Mapreduce), Spark Fundamentals I, Spark Fundamentals II (Spark ML}, SparkDL

Prerequisites: Operating Systems

CS510 Approximation Algorithms (6 Credits)

Brief Introduction to NP-completeness and approximation algorithms, greedy algorithms and local search, rounding data and dynamic programming, linear programming and relaxations, randomized approximation algorithms, Semidefinite programing, primal dual method, Metric Rounding of LP Relaxations, Hardness of approximations.

Prerequisites: NA

CS511 Introduction to Formal Verification and Its Applications (6 Credits)

Introduction to Formal methods of verification and model-checking; Modelling systems as finite-state systems; Introduction to first-order logic and temporal logics; Expressing properties in logics; Binary Decision Diagrams; Algorithms for LTL and CTL; Introduction to SPIN and NuSMV model-checker.

Prerequisites: NA

CS512 Parallel Algorithms (6 Credits)

Introduction: Different models of parallel computation, PRAM model and variations, interconnection networks, synchronous and asynchronous models, Performance Analysis.

Basic techniques: Matrix multiplications, Sorting, Searching and Selection, Balanced Trees, divide and conquer, partitioning, Pipelining, Tree contraction, Euler tour technique.

Graph Algorithms: Connected Components, Graph colouring, MST and shortest path algorithms.

Algorithms on Asynchronous model, Limit of Parallelizability, NC-reductions, P-completeness. Implementation: Introduction to Parallel Programming. Basic introduction to MPI and OpenCL.

Prerequisites: Design and Analysis of Algorithms, Programming with C

CS513 Electronic Payment Systems (6 Credits)

Evolution of currency; Traditional payment instruments: currency, cheques, demand drafts, debit systems etc; Credit systems: credit cards systems; Impact of communication networks, smart cards, introduction to various stakeholders and their roles in payment systems: Payment aggregators, payment gateways, payment processors etc.; Security aspects: Confidentiality, Integrity, Loss of control, loss of service. Dematerialized money and payment systems: Virtual money, digital money, electronic money etc. Purses, wallets; transactional properties: anonymity and traceability; payment settlement systems. Problems of identification, authentication,

authorization and settlements, cryptographic techniques for authentication using public key and symmetric key cryptosystems; password, tokens and biometric based authentications; case studies in India: EMV standards, metro ticketing, National mobility card, electronic toll collection, paytm and other wallet systems, NEFT, RTGS and IMPS systems, UPI, Aadhaar enabled payment systems (AEPS), frauds and dentification of frauds; safeguards etc; PKI concepts: certificates, non-repudiation, digital signatures, certification revocations; onefactor, two-factor and multifactor authentication.

Prerequisites: NA

CS515 Randomized Algorithms (6 Credits)

Introduction and basic tools: random sequence. Generating uniform random numbers: the linear congruential method and others. Statistical tests for random numbers: Chisquare test, Kolmogorov-Smirnov test, empirical I theoretical I spectral tests. Non-uniform random sequences.

Tools and techniques of randomized algorithms: game theoretic techniques, moments and deviations, tail inequalities.

the probabilistic method: Lovasz Local Lemma, Markov chains and random walks, algebraic techniques.

Applications: Data structures, hashing, linear programming, computational geometry problems, graph problems, approximate algorithms, parallel and distributed algorithms, cryptography, online algorithms. Derandomization techniques.

Prerequisites: NA

CS516 Parallelization of Programs (6 Credits)

Introduction to parallelization; Performance; Amdahl's law; Techniques for extracting parallelism from sequential programs; Compile-time parallelization: Dependency analysis; Dependency testing; Fine-grained parallelism -- loop interchange, reductions, node splitting, loop skewing, and loop peeling; Coarse-grained parallelism -- loop distribution and loop reversal; Control dependency; Runtime parallelization: Speculative execution, Inspector/Executor mechanisms, and Parallelizing irregular programs. Synchronization; Scheduling techniques; Parallelization for cache performance; Case studies.

Prerequisites: Compilers, Operating Systems, and Computer Organization

CS517 Software Defined Networking (6 Credits)

Overview of traditional networks, SDN origin and evolution, programmable control and data planes, network abstraction, northbound/southbound interfaces, OpenFlow protocol, centralized and distributed SDN, Open vSwitch, network function virtualization, service function chaining, network slicing.
Hands-on using Mininet and RYU/ONOS controller: Introduction to network emulator tools like Mininet and OpenFlow protocol supported controllers like RYU and ONOS.

Prerequisites: Basic Knowledge of Computer Networks

CS518 Simulation of Biology (2 Credits)

Cellular automata and Game of Life.
Coupled ordinary differential equations: SIR epidemiological model of disease spread.
Multi-Organism Interaction: Prisoner's dilemma, tit-for-tat, predator/prey models.

Prerequisites: Prior programming experience in Python/Java or another C-like language

CS519 High Performance Computer Architecture (6 Credits)

Single-core processors: Introduction - performance - pipelining and memory review. Parallel processors: Introduction - types of parallel architectures: data-parallel architectures, shared memory architectures, and distributed architectures - programming models.
Data parallel architectures: GPU architecture - programming for GPUs – synchronization - architectural optimizations -- performance issues - case studies.
Shared memory architectures: Multicore processors - cache coherence protocols - synchronization - memory consistency models.
Distributed memory architectures: Scalability - interconnect - message passing - programming models - directo -based cache coherence - communication optimizations..

Prerequisites: Computer organization or equivalent

CS525 Distributed System (6 Credits)

Definition of distributed systems.
Goals of distributed system: Openness, Dimensions of scalability, Architectural models, Implementation problems,Hardware organization, Types of Distributed Systems.

Concept of Clock: Notion of solar time and wall clock time, External Clock-based mechanisms, Logical clock, Temporal ordering of events, Birman-Schipher-Stephenson protocol, Schipher-Eggli-Sandoz protocol, Multicast message ordering.

Global States: Cuts and Global States, Algorithm for recording global states, Liveness and Safety, Termination detection: Ring, tree and weight throwing scheme.

Leader Election: Impossibility results, Bully algorithm, Ring-based algorithms, Distributed spanning tree algorithms: Single initiator and Multiple initiators, Leader election in trees.

Mutual Exclusion: Coordinator-based solutions, Non-token-based solutions, Lemport's algorithm, Recart-Agrawal's algorithm, Maekawa's algorithm, Token-based solutions: Suzuki-Kassami's algorithm, Singhal's algorithm, Raymond's tree-based algorithm.

Agreement and Consensus: Equivalence of consensus problems Byzantine General Problem and its solutions, Lamport-Shostak-Pease algorithm.

Prerequisites: Basic Knowledge about OS and N/W

CS550 Machine Learning (6 Credits)

Supervised Learning (Regression/Classification), Linear models: Linear Regression, Logistic Regression, Generalized Linear Models, Support Vector Machines, Nonlinearity and Kernel Methods, Multi-class/Structured Outputs, Ranking, Unsupervised Learning, Clustering: K-means/Kernel K-means, Dimensionality Reduction: PCA and kernel PCA, Matrix Factorization and Matrix Completion, Generative Models (mixture models and latent factor models), Assorted Topics, Evaluating Machine Learning algorithms and Model Selection, Ensemble Methods (Boosting, Bagging, Random Forests), Sparse Modeling and Estimation, Deep Learning and Feature Representation Learning.

Prerequisites: NA

CS551 Software Engineering (6 Credits)

Software Process Models, Requirement analysis and specification, Project planning & project monitoring, Design principles and structured design methodology, structured programming, verification concepts, Testing - testing purpose, levels of testing, black box testing, white box testing, different test case generation approaches.

Prerequisites: NA

CS552 Network Science (6 Credits)

Background, Graph theory related concepts, Network analysis metrics, Properties of many real networks, Network models and characteristics: Random Networks, Scale-free Networks, Small-world Networks, Community detection, Speeding Phenomena.

Prerequisites: NA

CS553 Cryptography (6 Credits)

Introduction and brief history; mathematics background; symmetric cryptography: one-time pad, stream ciphers, block ciphers, hash functions, message authentication codes,

authenticated encryption; information security vs. computational security: random function/permutation, pseudorandom function/permutation, integer factorization and discrete logarithm problems; asymmetric/public key cryptography: RSA and El Gamal based encryption and signature schemes; secret sharing; key distribution: Diffie-Hellman key agreement protocol, Kerberos; an advanced topic: Bitcoin-the first crypto-currency.

Prerequisites: NA

CS554 Blockchain Technologies (6 Credits)

Introduction to cryptography, Cryptocurrency, Mining, Proof of work, Proof of Stake, Differences between Cryptocurrency and Blockchain, Security properties of Blockchain, Blockchain Networks and Anonymity, Ethereum, Zcash, Regulation

Prerequisites: NA

CS555 Computer and System Security (6 Credits)

Basic Crypto: Public key and Private key Encryptions; Cryptographic protocols; Attack on Cryptographic protocols.

Operating System Security: Authentication and Authorization; Operating System and Program Security; Penetration Testing: Discovering and Exploiting Vulnerabilities; Malware Analysis; Security Policies and Models; Digital Rights Management and Trusted Computing.

Web Security: Pros and Cons of HTTPS; Cross site scripting; SQL Injection; Secure Session Management.

Network Security: Security aspects of TCP, DNS and Routing; Network defense tools: Firewall, Intrusion detection and filters; DDoS attack and defences.

Prerequisites: Computer organisation, Operating system, Programming language.

CS556 Hardware Security (6 Credits)

Fundamentals of hardware security and trust for integrated circuits. Cryptographic hardware, invasive and non-invasive attacks, side-channel attacks, physically unclonable functions (PUFs), true random number generation (TRNG), watermarking of Intellectual Property (IP) blocks, FPGA security, counterfeit ICs, hardware Trojans in IP cores and ICs.

Prerequisites: NA

CS557 eCommerce (6 Credits)

The objective of this course is to study the technologies and architectures that are in use in E-commerce today. The topics to be covered include:

Supporting technologies and tools, Architecture (e.g. Java commerce solution), Protocols and standards, Security, Business models, Payment mechanisms, and Case studies.

Prerequisites: NA

CS558 CAD for VLSI (6 Credits)

Introduction: IC design flow, High level design, HDL design Synthesis - Full-custom, standard-cell, gate-array and FGPA, Backend, Verification and Test of ICS.

High-level synthesis: Partitioning, scheduling, allocation and binding

Logic Optimization: Review of Karnaugh map and Quine-McCluskey based optimization, Espresso, State assignment and optimization

Physical design automation algorithms: Floor-planning, Partitioning & Placement, Routing: Global routing, Detailed routing.

Introduction Verification Techniques: Introduction to Hardware Verification and methodologies, Binary Decision Diagrams(BDDs) and algorithms over BDDs, Combinational equivalence checking, Temporal Logics, Modeling sequential systems and model checking

VLSI Testing: Introduction, Fault models, Fault Simulation, Test generation for combinational circuits, Test generation algorithms for sequential circuits.

Prerequisites: NA

CS559 Computer Systems Design (6 Credits)

Introduction to systems: Example Systems- Operating Svstems-Distributed File Systems Databases

Web Frameworks-Networks

Systems design intro: Setting goals for your system-Principles of good design

Modeling Fundamental: Quantitative Systems Design-Queuing Systems-Fundamental Laws and Applications-Asymptotic Bounds

Naming Schemes: Unix File System-Git-Network Naming

Caching: CPU Caching-CDN Caching

Resource Management: Scheduling-Load Balancing-TCP throughput Model

Other Topics: Virtualization-Security and Access Control-Reliability Models

Prerequisites: NA

CS599 Thesis (Variable Credits)

Students registering for this course are associated with a supervisor and have to carry out research work. Student will be evaluated for the program in research at the end of semester.

Prerequisites: This course is only for MTech student.

CS601 Cryptographic Protocols (6 Credits)

Security properties: privacy, correctness. fairness, robustness, independence of inputs: Semi-honest and malicious adversarial models; Universal composability; Commitment; Coin-flipping; Garbled circuit; Oblivious transfer: Yao's millionaires' problem; Secret sharing; GMW, BGW and BMR protocols; Fiat-Shamir Heuristic; Zero knowledge proofs: interactive and non-interactive; Pairing-based cryptography; Homomorphic encryption; Obfuscation; Witness encryption; Implementations: SPDZ and zkSNARK.

Prerequisites: CS553

CS607 Adversarial Machine Learning: Security and Privacy of ML (6 Credits)

Introduction of Machine Learning, Application and vulnerabilities.

Privacy and ML: Membership Inference Attack, Differential Privacy

Adversarial Attack and Defense: Decision Time Attack and Defense, Data Poinsoning Attack and Defense.

Attack and Defense of Deep Learning: 12, I., 111 norm attacks, Robust optimization, Retraining, Distillation,

Prerequisites: NA

CS608 Advanced Graph Algorithms (6 Credits)

Review of Intractability. Introduction to several hard graph problems. Design of efficient algorithms for hard problems on various graph classes: Interval graphs, chordal graphs, comparability graphs, planar graphs etc.
fixed-parameter tractability and intractability; kernelization; Techniques For parameterized algorithms, Tree-width and tree decompositions, structural graph parameters, randomized methods, lower bounds based on ETH.
Prerequisites: Basics of algorithms, graph theory

CS610 Lower Bounds and Impossibility (6 Credits)

Introduction to lower bounds, different techniques: counting, reduction, decision tree, indistinguishability, adversaries, valency, covering, graph theory and linear algebra. Lower bounds results in data structures, computational complexity theory, communication complexity theory, distributed computing, parallel computing.

Prerequisites: A course on Algorithm in Undergraduate level

CS611 Wireless Network & Mobile Data Management (6 Credits)

Introduction: Mobile and pervasive computing system, Characterizing mobile distributed system and mobile cloud system, Examples of mobile applications, Smart environments. Cellular wireless communication system: Frequency planning, Measurement of traffic intensity, Channel assignment, Handoff. GSM and GPRS system: GSM architecture, GSM Signaling protocols, GPRS architecture. WLAN: IEEE standards for WLAN, Topology, Spread spectrum, Wireless MAC. Routing protocols for mobile ad hoc networks: Classification of protocols, Proactive and reactive protocols, Distance vector-based protocols, DSDV, AODV. Mobile application protocols: Mobile IP, Mobile shell. Location management: Registration and paging, Two-tier scheme, Hierarchic scheme, Caching, and replication. Data dissemination and broadcast disks: Data delivery mechanisms, Broadcast disk, Memory hierarchy, Client-side cache management. Indexing in Air: Temporal address matching and directory, Tuning and access latencies, Distributed indexing scheme, Exponential indexing scheme

Prerequisites: Basic knowledge of computer networks

CS612 Introduction to Computational Complexity (6 Credits)

The Computational Model, Turing Machines, Decidability, Reducibility, Time Complexity, Space Complexity, Hierarchy Theorems, Boolean Circuits, Circuit Complexity, Limits of the

diagonalization method, Randomized Computation, Probabilistic Turing machine, Interactive Proofs, Introduction to Quantum Computation and Algorithms

Prerequisites: A course on Theory of Computation in Undergraduate level

CS613 Social and Complex Network Analysis (6 Credits)

Introduction to Structure of Graphs, Link Analysis: Page Rank, Random Graph Model, Network Construction and Inference, Motifs and Graphlets, Community Structure in Networks and Community Detection, Link Prediction, Graph Representation Learning, Network Effects and Cascading Behavior, Influence Maximization in Networks, Outbreak Detection in Networks, Network Robustness and Preferential Attachment, Network Centrality, Network Evolution, Knowledge Graphs and Metapaths, Network analysis tools: Networkx, Gephi, Cytoscape, Pajek etc.

Prerequisites: NA

CS614 Quantum Symmetric-Key Cryptanalysis (6 Credits)

1. Overview of quantum information and quantum computing: Qubits, quantum states, quantum gates, Superdense coding, Quantum circuits and reversible computation, (Partial) measurements, Quantum Entanglement, Quantum Teleportation, Deutsch's Algorithm
2. Quantum search: A simple searching algorithm: the Deutsch-Jozsa algorithm, Simon's algorithm, Amplitude amplification and Grover's Algorithm, Brassard Hoyer Tapp (BHT) Algorithm
3. Shor's factoring algorithm and its impact on cryptography.
4. Quantum Cryptanalysis: Quantum Adversarial/Attack Models, Application of Simon's and Grover's search algorithm in symmetric key cryptanalysis (Grovermeets- Simon, Offline Simon's Algorithm), Quantum security analysis of AES, Quantum collision finding on hash functions
5. Quantum resource estimation: Synthesis and optimization of quantum circuits.
6. Quantum Programming with Qiskit and ProjectQ

Prerequisites: CS553

CS795 Candidacy (0 Credit)

The objective of this candidacy is to evaluate the candidate’s ability to carry out research and shall include the evaluation of the knowledge breadth of the student, including the research comprehension.

Prerequisites: Student must have completed the course credit requirement for the program registered for.

CS798 Independent Study (variable Credits)

Students registering for this course are expected to get versed in a particular topic allotted by the course instructor. The topic and the credits are assigned by the course instructor. There will not be any regular lecture delivered for this course type.

Prerequisites: The course is available only to PG students.

CS799 Thesis (variable Credits)

Students registering for this course are associated with a supervisor and have to carry out research work. Student will be evaluated for the program in research at the end of semester.

Prerequisites: Student must have cleared candidacy.

Data Science and Artificial Intelligence

DS100 Mathematical Foundations of Data Science (4 Credits)

Bayes Rule and its connection to inference, various sampling methods, Modern PAC analysis (probably approximately correct).

Geometry of high-dimensional space, distance metrics used for numerical and text data. Locality sensitive hashing (LSH).

Matrix approximation techniques: Principal Component Analysis, SVD and dimensionality reduction.

Application of transforms (Fourier, Laplace) to data analysis.

Linear regression problem, gradient descent.

Introduce some representative datasets using images, documents and tables. Use Matlab/Python/R to demonstrate and explore basic concepts.

Prerequisites: NA

DS200 Architecture for Management of Large Datasets (6 Credits)

Design of distributed program models and abstractions, such as MapReduce, Dataflow and Vertex-centric models, for processing volume, velocity, and linked datasets, and for storing and querying over NoSQL datasets.

Approaches and design patterns to translate existing data-intensive algorithms and analytics into these distributed programming abstractions.

Distributed software architectures, runtime and storage strategies used by Big Data platforms such as Apache Hadoop, Spark, Storm, Giraph, and Hive to execute applications developed using these models on commodity clusters and Clouds in a scalable manner. Design of distributed program models and abstractions, such as Map Reduce, Dataflow and Vertex-centric models, for processing volume, velocity, and linked datasets, and for storing and querying over NoSQL datasets.

Approaches and design patterns to translate existing data-intensive algorithms and analytics into these distributed programming abstractions.

Distributed software architectures, runtime and storage strategies used by Big Data platforms such as Apache Hadoop, Spark, Storm, Giraph and Hive to execute applications developed using these models on commodity clusters and Clouds in a scalable manner.

Prerequisites: NA

DS201 Statistical Programming (4 Credits)

Probability and statistics: Review, Statistical measures and tests, Statistical analyses using Rand Python, and MATLAB, Linear Regression, Hypothesis Testing, Resampling Techniques, and Bootstrapping, Introduction to contemporary statistical packages

Prerequisites: NA

DS250 Data Analytics and Visualization (6 Credits)

Data science workflow, Automated methods for data collection, Data and Visualization Models, Data wrangling and cleaning, Exploratory data analysis

Building Models for: Classification, Clustering, Regression, Time-series, Association Analysis, Recommendation Systems.

Model evaluation, statistical tests for significance of predictors. Model regularization: ridge, lasso, elastic-net.

Visualization Software and Tools, Visualization Design, Multidimensional Data, Graphical Perception, Interaction dynamics for Visual Analysis, Using Space Effectively, Stacked Graphs, Geometry & Aesthetics.

Networks, Graph Visualization and navigation in information Visualization, mapping & Cartography, Text Visualization

Prerequisites: NA

DS251 Artificial Intelligence (6 Credits)

Problem solving, search techniques, control strategies, game playing (mini-max), reasoning, knowledge representation through predicate logic, rule-based systems, semantic nets, frames, conceptual dependency formalism. Planning. Handling uncertainty: Bayesian Networks, Dempster-Shafer theory, certainty factors, Fuzzy logic, Learning through Neural nets - Backpropagation, radial basis functions, Neural computational models - Hopfield Nets, Bolzman machines, MATLAB programming, introduction to Machine Learning, Supervised and Unsupervised Learning, Introduction to Machine Learning libraries

Prerequisites: NA

DS252 DSAI Lab (2 Credits)

Introduction, Data in Data Analytics, Descriptive Statistics, Programming with R, Probability Distributions, Sampling Distributions, Statistical Inference, Statistical Tables Relation Analysis, Analysis of Variance (ANOVA), Bayesian Classifier, Information Based Classification.

Support Vector Machine Sensitivity Analysis Similarity Measures.

Prerequisites: NA

DS500 Big Data Algorithms (6 Credits)

Introduction to big data and its peculiarities. Map Reduce as a datacenter-scale programming abstraction. Parallel algorithm design to process massive datasets. Algorithms to solve problems from a variety of domains: web search, e-commerce, social-networking, machine learning. Streaming Algorithms, sketching algorithms. Brief discussion of next generation systems like Spark and Flink.

Prerequisites: Introductory courses in probability, statistics, linear algebra and algorithms.

DS501 Information Retrieval (6 Credits)

Introduction, Document Indexing, Storage and Compression, Retrieval Models, Performance Evaluation, Text Categorization and Filtering, Text Clustering, Web Information Retrieval, learning to rank, Advanced Topics (Text Summarization, Question answering, Recommender Systems)

Prerequisites: NA

DS503 Advanced Data Analytics (6 Credits)

Analysis techniques for high dimensional datasets; Algorithms for massive data problems; Graph representation learning and Graph Neural Networks; Link Prediction, Graph and Node classification, Applications of Graph learning; Network algorithms including those for the World Wide Web; Clustering algorithms for high dimensional datasets; Advanced techniques for Time Series analysis: Motifs, Anomaly detection, Matrix Profile Technique

Prerequisites: DS250 or equivalent.

DS601 Digital Image Processing (6 Credits)

Fundamentals - Visual perception, image sampling and quantization; Intensity transformations - nonlinear transformations for enhancement, histogram equalization; Spatial filtering - convolution, linear and order statistic filters, unsharp masking. Image Transforms - discrete Fourier transform, discrete cosine transform; Transform domain processing - image smoothing, specialized filters (Gaussian, Laplacian, etc); Image restoration - using spatial filters, Wiener filter; Introduction to colour spaces and colour image processing; orphological image processing - erosion and dilation, opening and closing, hit-or-miss transform, thinning and shape decomposition; Binarization and Image segmentation - edge detection, thresholding, region-based segmentation; Image compression - fundamentals, lossless coding, predictive coding, transform coding.

Prerequisites: NA

DS602 Digital Speech Processing (6 Credits)

Review of digital signal processing: Discrete-time signals and systems, transform representation of signals and systems, fundamentals of digital filters, sampling.

Fundamentals of human hearing and speech perception: Speech production, acoustic phonetics, Anatomy and functions of the ear, the perception of sound, auditory models, lossless tube models

Time-domain and Frequency-domain methods for speech processing: Short-time analysis (energy, magnitude, zero-crossing rate, autocorrelation), Discrete-time Fourier analysis, short-time Fourier analysis, spectrograms, Overlap-add method of synthesis, filter-bank summation method of synthesis

Cepstrum and homomorphic speech processing: Homomorphic analysis, computing the short-time cepstrum and the complex cepstrum, cepstrum analysis of all-pole models, cepstrum distance measures

Linear predictive analysis of speech: Basic ideas, gain computation, frequency-domain interpretation, solving LPC equations, the prediction error signal, representations of LP parameters

Algorithms for estimating speech parameters: Median smoothing, speech-background discrimination, pitch period estimation, formant estimation

Digital coding of speech signals: Sampling speech signals, statistical models for speech signals, quantization (instantaneous, adaptive), quantising speech model parameters, delta modulation, DPCM, ADPCM
Applications: Speech recognition, speech enhancement, speaker recognition, Hidden Markov models for speech recognition, statistical methods for speech enhancement, factor anal sis for speaker recognition.

Prerequisites: Programming in Python/Matlab/C

Courses in Electrical Engineering

EE101 Signals and Processing (4 Credits)

Continuous-time and discrete-time signals and systems Random Processes, Linear systems, Fourier transform, Frequency response of LTI systems, Lowpass, highpass and bandpass filters, Z-transform, Sampling and reconstruction of bandlimited signals. Approximate reconstruction methods (ZOH, FOH), The Discrete Fourier transform and Fast Fourier transform (FFT) algorithm, Implementation of discrete-time systems using FFT.

Prerequisites: NA

EE102 Circuit Theory (6 Credits)

Introduction to Embedded Systems Design, Software Design Basics, ARM Cortex-M Processor Core, C Code as Implemented in Assembly Language, Interrupts, General Purpose Digital Interfacing, Analog Interfacing, Timers, Serial Communication.

Prerequisites: NA

EE103 Circuits and Systems (6 Credits)

Introduction to Signals, Fourier Series and Fourier Transform, LTI System, Laplace Transform, Convolution, Circuit Elements, AC Power and Phasor, Network Theorems: (KVL, KCL, Max. Power Transfer, Thevennin, Norton, Milimann, Star-Delta, Telegen). Dot Convention and Dependent Sources, Application of Laplace Transform in Circuit Analysis, Transient Analysis, Final value theorem and steady state analysis, Transfer Function, Resonance, Bode Plot, Introduction to Filters.

Prerequisites: NA

EE201 Electronic Devices (6 Credits)

Semiconductor Materials, concept of doping, majority and minority carriers, recombination and generation, temperature dependence of conductivity, Zener and avalanche breakdown, BJT, FET, JFET, MOSFET, Switching characteristics of devices: switching phenomenon in diodes, BJT, MOS & CMOS, switching times, switching speeds, Other elements: LED, Solar cells, Photo diodes, Thyristor, Resonant tunnel diode etc.

Prerequisites: NA

EE202 Control Systems –I (6 Credits)

Mathematical Modelling and Transfer Function, Signal Flow Graph, Feedback System, Time response analysis, Performance Indices, Frequency Response (Polar Plots), Stability Analysis (Routh-Hurwitz, Bode, Nyquist, Root Locus), Compensator Design (Lead, Lag, Lead-lag), PIO Controller. Introduction to MATLAB Control System Toolbox.

Introduction to State space and state variables, Eigen Vector, Canonical Forms, Observability and Controllability. MIMO systems.

Prerequisites: NA

EE203 Embedded Systems (4 Credits)

Concepts of embedded programming., Concepts of assembly language, Hardware-description language (VHDL/Verilog), High-level synthesis (using Synopsys Symphony C Compiler), Micro-controller programming.

Prerequisites: NA

EE204 Analog Circuits (6 Credits)

Semiconductor Materials, concept of doping, majority and minority carriers, recombination and generation, temperature dependence of conductivity, Zener and avalanche breakdown, BJT, FET, JFET, MOSFET, Switching characteristics of devices: switching phenomenon in diodes, BJT, MOS & CMOS, switching times, switching speeds.

Prerequisites: NA

EE205 Power Engineering–I (6 Credits)

Single phase AC systems: Introduction to real/reactive/apparent powers, power factor, introduction to phasors, phasor analysis and phasor diagram, poly phase AC systems.

Working principle, construction and applications of transformers, DC machine, AC, machines special machines and energy efficient motors.

Overview of the structure and components of power systems, major issues related to power systems.

Overview of power electronics devices and generic power electronic circuits.

Prerequisites: NA

EE206 Digital Signal Processing (4 Credits)

Review of Signal and Systems, Sampling and Data reconstruction processes, Z-transforms, Discrete linear systems, Discrete-Time Fourier Transform (DTFT), Frequency Domain Analysis of LTI Systems, Discrete Fourier transform and FFT algorithms, linear phase systems, FIR and IIR filters, Digital Filter Design principle with examples, Quantization effects in digital filters, Multi-rate signal processing: sampling rate conversion.

Prerequisites: NA

EE208 Electrical Machines (4 Credits)

Single phase AC systems: Introduction to real/reactive/apparent powers, power factor, introduction to phasors, phasor analysis and phasor diagram, poly phase AC systems.

Working principle, construction and applications of transformers, DC machine, AC, machines special machines and energy efficient motors.

Overview of the structure and components of power systems, major issues related to power systems.

Overview of power electronics devices and generic power electronic circuits.

Prerequisites: NA

EE251 Electrical Engineering Lab-I (2 Credits)

1. Design and Simulation of PID controller in Simulink and circuit implementation.
2. Position control of AC servo motor using Analog and Digital PID controller.
3. Position control of DC servo motor using Analog and Digital PID controller.
4. Speed control of DC servo motor using Analog and Digital PID controller.
5. Inverted pendulum on a cart - Linear model identification, PID control of cart position.
6. Inverted pendulum on a cart - Inverted pendulum control, real time pendulum swing-up control.
7. Magnetic levitation system - Non-linear model testing, model linearization, model identification.
8. Magnetic levitation system - PD and PID control of ball position.

Prerequisites: NA

EE301 Communication Systems-I (4 Credits)

Analog modulation techniques, Sampling, quantization and pulse modulation, Overview of multiplexing and multiple access techniques: TDM(A), CDMA, FDM and OFDM(A), Digital modulation techniques, Digital communication over bandlimited channels.

Prerequisites: NA

EE302 Engineering Electromagnetics (4 Credits)

General field properties; Review of vector calculus and coordinate systems; static electric fields, static magnetic fields; Biot-Savart and Ampere's laws; Boundary value problems and method of images; Magnetic vector potential, Materials: dielectric and magnetic materials, their properties, capacitance and inductance, applications, Transformers and electrical machines, Time-varying fields and Maxwell's equations in differential, integral and phasor forms. Wave equation., Transmission lines fundamentals. Smith Charts, Impedance matching. Waveguides: modal analysis of rectangular metallic waveguides, Antennas.

Prerequisites: NA

EE304 Computer Networks (6 Credits)

Basics and History of Computer Networks, TCP/IP protocol stack, Application layer (WWW, Email, DNS), Protocols at Transport layer, Network layer and Data link layer, Lab: Client-Server Design using Socket programming in C/C++/Java; Wireshark assignments on DNS, HTTP, DHCP, TCP, UDP, IP, Ethernet, ARP, etc. Network congestion, TCP vs UDP, IPv4 vs IPv6, Routing algorithms, Routing in Internet, ARQ protocols, Local Area Networks (Ethernet, Wi-Fi) and Multimedia Networking, Implementation of multi-threaded Web Server/Web Proxy with Caching/Filtering features, Sliding Window protocol implementation, performance study of various TCP/IP variants, Hands on with CISCO/HP routers; Introduction to software defined networks.

Prerequisites: NA

EE305 Semiconductor Device Modelling (6 Credits)

Lattice structure, Band diagram and transport phenomenon of Semiconductor, Physics of Schottky, homo- and hetero-junction junctions semiconductor, Compact modelling of P-N diode, BJT and HBT, MOS Capacitance, MOS transistors and its modelling, Introduction on SOI and SiGe, Layout and Parasitics.

Prerequisites: NA

EE306 Power Engineering – II (6 Credits)

Converters: basics of dc-dc converters in continuous mode; buck, boost and buck-boost converters, flyback converter, voltage source inverters, power electronic converters with ideal switching, Speed control of induction machines, Synchronous machines, Power system: structure of power systems, transmission lines, speed and voltage control, Introduction to DC systems and renewable energy.

Prerequisites: NA

EE307 Control Systems – II (6 Credits)

Introduction to Multivariable systems, Why Multivariable systems are important?, Interaction dynamics and its role on control system, design, Multivariable control-classical approaches, Structure, selection - variable pairing, tuning single loop controllers for MIMO, systems, Transmission zeros and transmission zero direction, Advanced control approach, State space representation, Conversion from SS to/from TF, Controllability, Observability, State transfer problem, solution to state transfer problem, pole placement controller design, Design of observer, Kalman filter design, Model (observer) based predictive controllers, LQR/LQG, various MPC schemes.

Prerequisites: NA

EE308 Information Theory and Coding (6 Credits)

Entropy, Relative Entropy, and Mutual Information, Typical Sequences and Asymptotic Equipartition Property, Source Coding and Data Compression, Channel Capacity, Differential Entropy and Gaussian Channel, Linear Binary Block Codes, Convolutional Codes.

Prerequisites: NA

EE309 Power Electronics (6 Credits)

Characteristics of semiconductor power devices: Diode, Thyristor, Triac, GTO, MOSFET, IGBT; DC to DC conversion: Buck, Boost and Buck-Boost converters; Single and three phase configuration of uncontrolled rectifiers, Line commutated thyristor based converters, Bidirectional ac to de voltage source converters, Issues of line current harmonics, Power factor, Distortion factor of ac to de converters, Single phase and three phase inverters, Sinusoidal pulse width modulation.

Prerequisites: NA

EE311 Advanced Digital Circuits (4 Credits)

Computer Arithmetic for data path design: Fast adders, multipliers, dividers. Design of basic computer components such as arithmetic logic units, Embedding a Soft-core microcontroller.

Prerequisites: NA

EE353 Electrical Engineering Lab-IV (4 Credits)

Selected experiments on following topics of Circuit Theory, Semiconductor Devices and Analog Circuits:

1. BJT and diode - single transistor amplifier and rectifier.

2. FET - Determination of equivalent Model by AC small signal analysis.

3. Op amp - Open and closed loop characterization, Bode plots, Realization of Inverting and non-inverting amplifiers.

4. Mathematical operation with Op amps - summing, differentiating, log and antilog amplifiers, integrator and differentiator.

5. RC and RLC circuits - C-V characterization, time and frequency response, resonance.

6. Twin-T network - Determine of two port parameters (Z, Y, ABCD and hybrid parameters) study on filtering action of Twin T.

7. Signal generators and Multivibrators-Sine, Square and Triangular wave generator.

8. Design of Active filters: Sallen-key and State variable filters.

9. Gyrator circuits: Op amp based inductor realization and negative resistors.

Prerequisites: NA

EE401 VLSI Technology (6 Credits)

Environment for VLSI Technology, Crystal defects, Wafer cleaning processes and wet chemical etching techniques; Impurity incorporation; Oxidation; Lithography :Photolithography, E-beam lithography and newer lithography techniques for VLSI/ULSI; Mask generation; Chemical Vapor Deposition techniques : CVD techniques for deposition of polysilicon, silicon dioxide, silicon nitride and metal films; Epitaxial growth of silicon; modelling and technology; Metal film deposition : Evaporation and sputtering techniques. Failure mechanisms in metal interconnects; Multi-level metallisation schemes; Plasma and Rapid Thermal Processing: PECVD, Plasma etching and RIE techniques; RTP techniques for annealing, growth and deposition of various films for use in ULSI; Process integration for NMOS, CMOS and Bipolar circuits; Advanced MOS technologies.

Prerequisites: NA

EE402 Beyond Moore Electronics (6 Credits)

3-D ICs Fabrication, Modeling &Design Challenges, Molecular Electronics Fabrication, Modeling Challenges (Bottom up approach), Other Si electronics, Spintronics, Beyond CMOS technologies.

Prerequisites: NA

EE403 Renewable Energy Systems (6 Credits)

Introduction to Renewable Energy, Worldwide scenario, Indian Scenario, Primary attributes of different renewable energy sources; Solar Thermal, Solar Photovoltaics, Wind energy, Bio Energy, Geothermal energy, other renewable sources, integration of renewable energy to the grid.

Prerequisites: NA

EE404 Power System Analysis (6 Credits)

Power Systems Evolution of Power Systems, Energy Sources Structure of Bulk Power Systems Basic three phase system concepts Power System Components: Generators, Loads, Transformers, Transmission Lines etc. Modelling, Performance and Constraints of these components Formulation/Solution of steady state equations for interconnected systems: Balanced and Unbalanced systems. Positive Sequence Network, Per Unit System, Y-bus formation Simple example of a load flow solution Introduction to generator swing equations and stability issues, Simple Example of Loss of synchronism Interconnected System Operation and Control: Operational Objectives, Frequency Control, Voltage Control and Power Flow Control: introduction to HVDC transmission and FACTS Economic Issues in Power Systems. Analysis of Faulted Power Systems and Protection: Unbalanced System Analysis using Sequence Components, Equipment Protection Schemes: Overcurrent, Differential and Distance Protection, Relay coordination Preventive Control and Emergency Control System Protection Schemes) Blackouts and Restoration

Prerequisites: NA

EE499 Thesis (Variable Credits)

Students registering for this course are associated with a supervisor and have to carry out research work. Student will be evaluated for the program in research at the end of semester.

Prerequisites: This course is only for BTech Honours student.

EE501 Nanoelectronics (6 Credits)

Introduction to the principles of quantum mechanics, Quantum-mechanical origin of the electrical and optical properties of materials and nanostructures, absorption, luminescence, transport including tunneling in low-dimensional semiconductors, transport in nano-MOSFET, Emerging nanomaterials and structures including graphene, graphene nanoribbons, carbon nanotubes; Nanostructured devices, Nano-electromechanical systems, Quantum-dot cellular automata.

Prerequisites: NA

EE502 Smart Grids (6 Credits)

Part - I Smart Grid (SG) Core Concepts: SG Conceptual Model, SG Architectures, SG Standards, SG Regulatory Perspective, SG Technologies. Part - II Smart Grid Practical Aspects: Initiatives around the world, Initiatives in India, India Smart Grid Vision and Roadmap

(2012 - 2027), SG standards development in India, SG Pilot Projects in India, Challenges and way forward.

Prerequisites: NA

EE503 HVDC Transmission (6 Credits)

1) Comparison of Ac and De Transmission Systems: Advantages and Disadvantages.
2) Fundamentals of the Rectification and Inversion Process, Mathematical Analysis of the HVDC Converter.
3) Operation of semiconductor device: Thyristor valve.
4) Control of HVDC Systems.
5) Fault Detection and Protection.
6) Reactive Power Requirement and Filter Designfor HVDC Systems.
7) Analysis of Maximum Power Transfer Capability and Steady-State Stability of HVDC Systems.
8) Emerging HVDC topologies (Voltage Sourced HVDC Converters, Multi-Modular Converter)
9) Ground Electrodes and De Transmission Lines
10) Use of Simulation Tools in analysis and Design of HVDC Systems

Additional advanced research topics as determined by the instructor.

Prerequisites: Power Engineering / Power System course at UG level.

EE504 Design of Analog and Mixed Signal Circuits (6 Credits)

OP AMP: Non ideal characteristics and analysis. Design of continuous time active filters: (i) Approximation functions: Butterworth, Chebyshev & Bessel approximations, (ii) Biquad Filters. Sallen Key and other filter configurations, cascade filter, GIC. Sample data filter: Switch capacitor filter; filter transfer function in z-domain. Mixed signal circuits: Introduction to switched current filter, current cell. Simple second order structure. Analog multiplexer, Sample and Hold Circuits, aliasing error and anti-aliasing filter, DAC& ADC. Over sampling method for A/D and D/A conversion. Delta-Sigma data converter. Noise and noise reductions. Interference signals and their reduction. Logarithmic and exponential amplifiers, analog multipliers and divider. Waveform generator and Oscillators, Voltage controlled

oscillator and Phase locked loop. Introduction to OPERATIONAL TRANSCONDUCTANCE AMPLIFIERS: characteristics and applications. PSpice simulations, PCB design and layout.

Prerequisites: NA

EE505 Power System Operation Optimization (6 Credits)

Power flow analysis; Power system security; Sensitivity calculations; Economic Dispatch - Classic, Security-constrained and Multi areas' system; Unit commitment; Optimal power flow; Optimal load shedding; Optimal reconfiguration of electrical distribution network; Uncertainty analysis in power systems; Integration of renewable energy.

Prerequisites: Introductory level full-semester course on Power Systems / Power Systems Analysis.

EE506 Power Systems Planning (6 Credits)

Elements of economics, finance and regulation as applied to the power sector, in general, and power generation, in particular; Load-demand forecasting; Generation system reliability - concepts, measures and methodology of evaluation; Overview of generation system production simulation and analysis; Generation capacity planning; Bulk power transmission planning

Prerequisites: Introductory level full-semester course on Power Systems / Power Systems Analysis.

EE507 Sensors, Measurement, and Instrumentation (6 Credits)

Basics of measurement and Instrumentation: Characteristics, calibration and Error Analysis, Electrical Measurements: (i) bridge circuits for R, L, C measurements, (ii) wattmeter and energymeter (iii) dynamometers, potentiometers and instrument transformers. An introduction to sensors: (i) temperature sensors (ii) force and pressure sensors (iii) motion sensors and LVDT, (iv) flow sensors (v) Hall effect sensors. Signal conditioning circuit design (bridge and filter circuits, instrument amplifier) and microcontroller based signal processing and display (using Arduino board).

Prerequisites: NA

EE508 Fundamentals of Wireless Communication (6 Credits)

Wireless channels: Modeling of wireless channels; the wireless channel as a random linear time-varying (LTV) system; stochastic characterization of LTV systems; the wide-sense stationary uncorrelated scattering (WSSUS) assumption; characterizing key parameters of wireless channels; discretization and discrete-time representation.

Diversity: Non-coherent and coherent reception; error probability for uncoded transmission; realizing diversity; time diversity: interleaving, constellation rotation; frequency diversity: spread spectrum systems and the Rake receiver; code design for wireless channels: the product distance design criterion; diversity order estimates on the basis of the scattering function.

Information theory of wireless channels: Entropy and mutual information; capacity of the Gaussian channel and of parallel Gaussian channels; capacity of fading channels: ergodic capacity and outage capacity; high versus low SNR regime; water filling capacity.

Multiple-Input Multiple-Output (MIMO) wireless systems: Capacity of MIMO wireless systems; spatial multiplexing; space-time coding.

Cellular. systems: Multiuser communications; multiple access and interference management; CDMA and FDMA schemes; multi-user diversity.

Prerequisites: Probability theory with emphasis on Gaussian random processes; signal space concepts, linear algebra, Communications Systems-I.

EE509 Power Electronics (6 Credits)

Characteristics of semiconductor power devices: Diode, Thyristor, Triac, GTO, MOSFET, IGBT; DC to DC conversion: Buck, Boost and Buck-Boost converters; Single and three phase configuration of uncontrolled rectifiers, Line commutated thyristor based converters,

Bidirectional ac to de voltage source converters, Issues of line current harmonics, Power factor, Distortion factor of ac to de converters, Single phase and three phase inverters, Sinusoidal pulse width modulation. Advanced topic on modulation techniques, HVDC, and FACTS.

Prerequisites: NA

EE510 Advanced Topics in Digital Signal Processing (6 Credits)

Review: sampling theory & basic DSP concepts, Multi-rate signal processing and filter

banks, Time-frequency analysis, STFT, wavelet transform, Linear prediction and optimum linear filters, Adaptive filtering, Compressed sensing & sparse recovery.

Prerequisites: Probability and random processes, linear algebra, Signal Processing

EE512 Advanced and Digital Control System (6 Credits)

Revision to linear vector space, State space and state variables. Canonical Forms, Observability and Controllability, Ackerman's Formula, LQR/LQG problem, Solving of Riccati equation using eigenvalue and eigenvector, Internal Stability, Lyapunov and asymptotic stability. Model based predictive controller, Simulation in MATLAB Simulink.

Fundamental of non-linear control, linearization, describing function, phase plane analysis, limit cycles, Lyapunov and BIBO stability, Aizermans and Kalmans conjecture.

Discretization of continuous system, Z-transform, basics of digital control, optimization problem, Kalman filter design, artificial neural network and fuzzy control.

Prerequisites: NA

EE515 Wireless Communication Security with SDRS (6 Credits)

Introduction to SDRs; Security analysis of simple systems: Key-Fobs; Bluetooth Security analysis: Protocol Description followed by sniffer analysis; WiFi Security analysis: Protocol Description followed by sniffer analysis; L TE Security analysis: Protocol Description followed by sniffer analysis; Study of attack models for selective protocols.

Prerequisites: Basic Networking Knowledge

EE521 Analog IC design (6 Credits)

Fundamentles of Analog IC Design: Analog MOS transistor models - Fundamentals and analog IC specification parameters -Threshold voltage - MOSFET I-V and C-V characteristics - characterization of resistive - capacitive elements of MOS devices.

Second order effects: Body Effect -Subthreshold leagake- DIBL - GIDL - Velocity Saturation -

Hot electron effect.

Basics of single stage amplifier: MOS small signal model - Small signal analysis of common

source, common drain, common gate and cascade stage amplifier with various kind of loads.

Current mirrors: Various architectures, active current mirrors, Wiloson current source and

modified version.

Frequency response of amplifiers.

CMOS Differential Amplifiers with balanced and unbalanced output - CMOS Operational Amplifiers: telescopic - differential amp - folded cascade - multistage architecture - Common mode feedback (CMFB) circuits.

Feedback topologies in amplifiers: Voltage Shunt - Voltage Series - Current Shunt - Current Series type feedback.

Stability and frequency compensation.

Noise in amplifiers: Thermal noise - 1/f noise - Switching noise - Shot noise.

Non-linearity and mismatch analysis.

Switch capacitor circuits. Oscillators: LC oscillator and ring oscillators, VCO and PLL.

Analog layout Design: Common centroid - Uses of dummies -Antenna effect- Multiplier and finger structure, Latchup and prevention techniques - IO pad design - Supply, ground, and signal routing - Shielding techniques to remove crosstalk, deep n-well technique, Electrostatic Descharge: Iluman body model - Charged device model - Machine model – ESD Protection circuitry design.

Prerequisites: NA

EE523 Power System Analysis (6 Credits)

Power Systems Evolution of Power Systems, Energy Sources Structure of Bulk Power Systems Basic three phase system concepts Power System Components: Generators, Loads, Transformers, Transmission Lines etc. Modelling, Performance and Constraints of these components Formulation/Solution of steady state equations for interconnected systems: Balanced and Unbalanced systems. Positive Sequence Network, Per Unit System, Y-bus formation Simple example of a load flow solution Introduction to generator swing equations and stability issues, Simple Example of Loss of synchronism

Interconnected System Operation and Control: Operational Objectives, Frequency Control, Voltage Control and Power Flow Control: introduction to HVDC transmission and FACTS Economic Issues in Power Systems. Analysis of Faulted Power Systems and Protection: Unbalanced System Analysis using Sequence Components, Equipment Protection Schemes: Overcurrent, Differential and Distance Protection, Relay coordination Preventive Control and Emergency Control System Protection Schemes) Blackouts and Restoration, Discussion on some advanced topics of Power System Stability, Synchronous Machine, and Power System Operation and Control.

Prerequisites: NA

EE525 Renewable Energy System (6 Credits)

Introduction to Renewable Energy, Worldwide scenario, Indian Scenario, Primary attributes of different renewable energy sources; Solar Thermal, Solar Photovoltaics, Wind energy, Bioenergy, Geothermal energy, other renewable sources, Integration of renewable energy to the grid.

Prerequisites: NA

EE526 Digital IC Design (6 Credits)

Introduction, MOS Transistor Basics and Theory. Threshold voltage, MOSFET I-V and CV characteristics, characterization of resistive, capacitive elements of MOS devices. Logic implementation by CMOS. Static CMOS invertor and its Transfer characteristics.
Transistor sizing, Technology scaling, Gate delay and power models. Static and Dynamic characteristics, Noise margins, Interconnect basics and crosstalk. Logical effort, Electrical effort, intrinsic/extrinsic delay. Circuit topologies and transistor sizing for optimal delay and power. Circuit Styles: Static CMOS circuits, Pass transistor logic, Transmission gate, Dynamic CMOS, Dual-rail-domino logic, Pseudo MOS logic and other families. Combination circuit design with various architectures. Sequential circuit design, Basic understanding, design, and timing analysis of sequential circuits like Flip- Flops and Latches. Time borrowing and pipelining. Circuit pitfalls, Clocking techniques, and Layout design basics. Memory design, EEPROM, DRAM, SRAM, and sense amplifiers. IOs, Low Power Techniques, Design methods and tools, CMOS testing, System Design Examples.

Prerequisites: NA

EE529 Introduction to Wireless and Cellular Communications (6 Credits)

Overview of Cellular Systems and evolution 2G/3G/4G/5G, Cellular Concepts - Frequency reuse, Co-channel and Adjacent channel Interference, Handoff, Blocking, Erlang Capacity, Wireless propagation- Link budget, Free-space path loss, Noise figure of receiver, Wireless propagation - Multipath fading, Shadowing, Fading margin, Shadowing margin, Antenna Diversity, Wireless Channel Capacity, MIMO, CDMA, OFDM and LTE, Large Scale Propagation effects and Channel Models.

Prerequisites: Communication Systems

EE543 Fundamentals of MLOps (2 Credits)

This hands-on course introduces participants to MLOps tools for deploying, automating, evaluating, monitoring, optimizing and operating production ML systems on practically available solutions including Google Cloud, Microsoft Azure, AWS Sagemaker, etc. Types of databases to be used for continuous functioning of the system. Data storage vs usage trade-offs. Repeatability in training. Analysis of pricing models of the possible solutions. KPIs offered by different solutions and their relevance to the nature of the ML problem.

Prerequisites: Basic Python-based ML Algorithm Usage, and Networking Knowledge

EE555 Mathematical Methods – I (6 Credits)

Linear Algebra: Linear Equations, Vector Spaces, Linear Transformations, Polynomials, Determinants, Elementary canonical Forms, Rational and Jordan Forms, Inner Product Spaces, Operators on Inner Product Spaces.

Probability and Random Processes: Introduction to Probability Theory, Random Variables, Conditional Probability and Conditional Expectation, Markov Chains, The Exponential Distribution and the Poisson Process, Renewal Theory and Its Applications, Queueing Theory, Simulation

Optimization Theory: Optimization in R^n, Existence of Solutions, Kuhn-Tucker Theorem

Markov Decision Processes and Finite Horizon Dynamic Programming.

Prerequisites: NA

EE556 Mathematical Methods—II (6 Credits)

Mathematical Analysis: Real and complex numbers systems, Set theory, Point set topology, Limits and continuity, Derivatives, Functions of bounded variation and rectifiable curves, Riemann-stieltjes integral, Infinite series and Infinite Products, Sequence of Functions, Implicit Functions and Extremum Problems, Cauchy's theorem

Differential Equations: Separable Equations, First-order Equations, Second-order Linear Equations, Power Series Solutions and Special Functions, Partial Differential Equations and Boundary Value Problems, Systems of First-Order Equations, The Existence and Uniqueness of Solutions, Numerical Methods.

Prerequisites: NA

EE566 Math of Turn-based Strategy Games (3 Credits)

Basics: Markov Chains - Markov Decision Processes (MOP} - Dynamic Programming. Game Classification: Turn-based Strategy (TBS} games - Real-time Strategy (RTS) games. Game Modelling: Application of MDPs to Modelling and Analysis of the TBS games Case studies: Compact Conflict or World Wdrs 2 - Variations of the selected game.

Prerequisites: Basic Probability Theory

EE567 Math of Machine Learning (3 Credits)

Basic Definitions: Convex functions and sets, Introduction to Theory of Learning: meaning of learning, overfitting etc, Gradient and Sub-gradient descent for non-smooth functions eg: SVM, Online Gradient Descent eg: SGD and its applications (NN), Duality and its examples, Bayesian Machine Learning, Estimating decisions using posterior distributions, Model selection: Variational Inference.

Prerequisites: Basic Calculus and Linear Algebra

EE599 Thesis (Variable Credits)

Students registering for this course are associated with a supervisor and have to carry out research work. Student will be evaluated for the program in research at the end of semester.

Prerequisites: This course is only for MTech student.

EE601 Solar Photovoltaic Devices and Systems (6 Credits)

Importance of photovoltaics in the present world scenario, Review of semiconductor fundamentals, Design of solar cells, Solar cell technologies, Emerging concepts, Solar PV modules, Balance of solar PV systems, PV system design and applications.

Prerequisites: NA

EE602 Application of Stochastic Geometry in Wireless Networks (6 Credits)

Basics of spatial point processes and stochastic geometry, Outage and interference in random wireless networks, Applications to multi-antenna systems, power control, bandwidth partitioning, opportunistic relay selection, Multi-tier cellular networks, ARQ and local-connectivity delay, Non-Poisson networks (cluster, cognitive and CSMA), A final mini-research project to help students explore more advanced topics in this subject.

Prerequisites: NA

EE603 Multi-Antenna Digital Communications (6 Credits)

Preliminaries: Review of Gaussian random variables and vectors, Complex Gaussian random vectors, Detection in Gaussian noise, Probability of error, union bound, some definitions and results from Information theory Capacity of the vector Gaussian or MIMO channel, Ergodic Capacity of multi-antenna Gaussian channels with Rayleigh fading, Outage capacity of multi-antenna Gaussian channels with fading Spatial multiplexing: V-BLAST Space-time codes: Design criteria, Alamouti code, Orthogonal designs, Quasi-orthogonal space-time codes, Diversity-multiplexing gain trade-off MIMO with feedback: Long-term and short-term power constraints, delay-limited capacity Multiuser MIMO: Multiple access, broadcast.

Prerequisites: NA

EE604 Signal Processing Algorithms to DSP Architectures (6 Credits)

Architectures for VLSI implementation of signal processing systems - Multi-core, many-core, hardware accelerators - Metrics for analysis and comparison of architectures - DSP algorithms, properties relevant to hardware realizations - Modifications to algorithms to improve hardware realizability - Models such as dataflow graphs and their use in architecture exploration - Communication architectures, networks on chip - Specialized architectures for DSP functions.

Prerequisites: NA

EE605 Advanced Computer Networks (6 Credits)

Basics of Computer Networking, TCP/IP protocol stack, Local Area Networks (Ethernet, Wi-Fi), Network Management, Network Security, Multimedia Transport, Next generation Internet architectures.

Prerequisites: NA

EE606 5G NR Systems: Physical Layer Aspects (6 Credits)

Physical layer General description, Physical layer services provided by the physical layer, Physical channels and modulation, Multiplexing and channel coding, Physical layer procedures for control, Physical layer procedures for data, Physical layer measurements, Physical layer procedures for shared spectrum channel access.

Prerequisites: Digital Signal Processing, Wireless Communications, Probability and Random Processes

EE610 Application of power Electronics to power System (6 Credits)

Load Balancing, reactive power compensation and active filtering techniques. Flexible AC transmission systems (FACTS). Principles of series and shunt compensation. Description of static var compensators (SVC), Thyristor Controlled series compensators (TCSC), Static phase shifters (SPS), Static compensator (STATCOM), Static synchronous series compensator (SSSC) and Unified power flow controller (UPFC). Modelling and Analysis of FACTS controllers. Control strategies to improve system stability. High Voltage DC Transmission System (HVDC), and their control.

Prerequisites: EE509 Power Electronics

EE611 Introduction to Information Theory and Coding (6 Credits)

Information, discrete memoryless source, entropy, mutual information, capacity, source and channel coding theorems, Shannon's capacity formula, rate-distortion theorem, differential entropy, Linear Binary Block Codes, Convolutional Codes, Turbo Codes, LDPC codes, Polar codes. Applications of coding theory in 4G and SG systems..

Prerequisites: Basic Understanding of Probability and Random Variable

EE701 Wireless MAC Modelling (6 Credits)

Markov Chains - Discrete Time, Continuous Time, State classifications, Birth Death processes, Network of queues MAC protocols - CSMA/CA, QoS parameters - Reliability, Latency, State diagram of CSMA, 2 Dimensional Markov Model of CSMA, 3 Dimensional Markov Model of CSMA.

Prerequisites: NA

EE777 Mobile Communications Systems (6 Credits)

General Introduction: ITU definitions, Standardization Bodies, Brief History of Mobile Communications Systems, IEEE and 3GPP Family of Technologies, Wireless Spectrum.

Radio Access Network: 4G and SG Systems. Physical Layer/MAC: OFDMA and SC-FDMA, Uplink and Downlink Scheduling (proportionally fair, etc), HARQ, Transport Block Size, Modulation and Coding Index Determination, MIMO and Precoding, Multiple Access, Cell Search, PLMN Search, Random Access. SG NR Frame Structure. Radio Protocols: RLC, PDCP, SOAP, RRC. Mobility: Neighbouring Cell Measurements, Lossless and Lossy Intra-system Handovers

Performance and System Design: Layer 1 peak bit rates, link budget, spectral efficiency, latency, Terminal Categories

End-device Hardware Design: Design for different terminal category support.

Core Network: IP Address management, Mobile IP, 1Pv6 in 3GPP, Tunnelling, SON and NFV aspects.

Applications: Multimedia Broadcast Multicast Service, Secure User-Plane Location for Assisted GPS, Edge Computing,

Multimedia Communications Support, Voice over LTE, AR/VR Delivery, uRLLC, Machine Type Communications, eMBB, V2X over SG.

Prerequisites: NA

EE795 Candidacy (0 Credit)

The objective of this candidacy is to evaluate the candidate’s ability to carry out research and shall include the evaluation of the knowledge breadth of the student, including the research comprehension.

Prerequisites: Student must have completed the course credit requirement for the program registered for.

EE798 Independent Study (variable Credits)

Students registering for this course are expected to get versed in a particular topic allotted by the course instructor. The topic and the credits are assigned by the course instructor. There will not be any regular lecture delivered for this course type.

Prerequisites: The course is available only to PG students.

EE799 Thesis (variable Credits)

Students registering for this course are associated with a supervisor and have to carry out research work. Student will be evaluated for the program in research at the end of semester.

Prerequisites: Student must have cleared candidacy.

Courses in Mathematics

MA200 Differential Equations (2 Credits)

First order linear ordinary differential equations, Bernoulli's equations, exact differential equations and integrating factor, solutions of second and higher order linear differential equations with constant coefficients.

First order linear partial differential equations, quasi-linear PDE, method of characteristics, Cauchy problem; classification of second order partial differential equation, separation of variable method for heat, Laplace and wave equations.

Prerequisites: NA

MA201 Complex Variables (2 Credits)

Complex numbers and elementary properties, complex functions - limits, continuity and differentiability. Cauchy-Riemann equations, Laplace equations, analytic functions and harmonic functions, path integrals, Cauchy-Goursat theorem, Cauchy integral formula, derivations of an analytic function, Taylor series, power series, Laurent series, zeros, singularities, Cauchy's residue theorem and applications.

Prerequisites: NA

MA202 Transform Techniques (2 Credits)

Laplace transform, inverse Laplace transform, properties, Laplace transforms of derivatives and integrals, partial fractions, unit step function, t-shifting, applications of Laplace transform to differential equations; Fourier integral and Fourier transform, inversion, convolution, applications of Fourier transform to differential equations.

Prerequisites: NA

MA500 Real Analysis (6 Credits)

Real valued functions of real variables, continuity, intermediate value theorem, differentiability, mean value theorem and applications, Riemann integral and its properties, improper integrals.

Sequences and series of functions: uniform convergence, equicontinuity, Arzela-Ascoli's theorem.

Construction of Lebesgue measure, measurable functions, Lebesgue integration, abstract measure and abstract integration, monotone convergence theorem, dominated convergence theorem, Fatou's lemma, comparison of Riemann integration and Lebesgue integration.

Prerequisites: NA

MA501 Linear Algebra (6 Credits)

Systems of linear equations, matrices and elementary operations, row-reduced echelon matrices, solutions of linear systems: existence and uniqueness. vector spaces, subspaces, spanning space, bases and dimensions, ordered basis and coordinates, linear transformations, matrix representations of linear transformations, range space and rank, null space and nullity, the rank and nullity theorem, invertibility.

Eigenvalues and eigenvectors, the characteristic polynomial, the Cayley- Hamilton theorem, the minimal polynomial, algebraic and geometric multiplicities, diagonalization, the Jordan canonical form.

Prerequisites: NA

MA502 Modern Algebra (4 Credits)

Groups: Definition of group and its properties, subgroups, coset of a subgroup, Lagrange's theorem. Cyclic groups, normal subgroups, quotient groups. Homomorphism, isomorphism theorems. Group actions, Sylow's theorem. Direct products of groups actions.

Rings: Definition of ring with examples, homomorphism theorems, ideals and its properties, two• sided ideals, prime and maximal ideals. The Chinese Remainder Theorem; Maximal and prime ideals; Unique factorization domains, principal ideal domains, Euclidean domains, universal property of a polynomial ring; Criteria for irreducibility, Concept of field and related examples.

Prerequisites: NA

MA503 Introduction to Probability Theory (4 Credits)

Introduction to probability, probability spaces, conditional probability, Bayes' theorem and independence of events; Random variables -discrete and continuous, probability mass, probability density and cumulative distribution functions, joint distributions, independence, mathematical expectations, moments, covariance, correlation, Chebyshev's inequality; Special distributions: binomial, hypergeometric, Poisson, exponential, uniform, normal distributions.

Random sampling, sample mean, sample Variance, weak and strong law of large numbers, central limit theorems.

Prerequisites: NA

MA504 Differential Equations (4 Credits)

A review of first order equations, Picard's existence and uniqueness theorem, second order differential equations with constant coefficients - wronskian, method of variation of parameters; Series solution of second order linear equations: ordinary points, regular singular points, Legendre polynomials and properties, Bessel functions and properties. Systems of first order differential equations.

First order linear and quasi-linear partial differential equations (PDEs), Cauchy problem, classification of second order PDEs. Solutions methods for Poisson's, Laplace's and heat equations.

Prerequisites: NA

MA505 Complex Analysis (6 Credits)

Complex numbers, holomorphic functions, Cauchy Riemann equations, harmonic functions, Cauchy theorem and Cauchy's integral formula, Taylor and Laurent series, Liouville's theorem, open mapping theorem; The maximum -modulus theorem, isolated singularities, residue theorem, the argument principle, real integrals via contour integration. Mobius

transformations, conformal mappings. The Schwarz lemma, automorphisms of the disc. The Riemann mapping theorem.

Prerequisites: NA

MA506 Multi-Variable Calculus (4 Credits)

Functions of several variables, continuity, directional derivatives, partial derivatives, total derivative, higher order derivatives and Taylor's theorem, maxima-minima problems, critical points, saddle points and the Hessian, constrained extrema and Lagrange's multipliers; The inverse and implicit function theorem; Integration on R", differential forms on R", closed and exact forms; Green's theorem and its applications, Stokes' theorem and Gauss's divergence theorem.

Prerequisites: NA

MA507 Numerical Techniques (6 Credits)

Linear systems of equations, direct and iterative schemes, ill conditioning and convergence analysis, sources of errors, solutions of nonlinear equations, Numerical Schemes for non-linear systems, bisection method, Newton's method and its variants, fixed point iterations,

convergence analysis; Finite differences, polynomial interpolation, Hermite interpolation, spline interpolation; Numerical integration - Trapezoidal and Simpson's rules, Gaussian quadrature, Richardson extrapolation; Initial value problems - Taylor series method, Euler and modified Euler methods, Runge-Kutta methods, single step, multistep methods, order, consistency,stability and convergence analysis; Numerical solution of differential equations; Boundary value problems: Shooting and finite difference methods.

Prerequisites: NA

MA508 Topology (6 Credits)

Definition of topological spaces and examples, bases, product topology, subspace topology, metric topology, quotient topology, second countability and separability; Continuous functions on topological spaces, homeomorphisms, connected set, examples, path connectedness and local connectedness.

Compact set and examples, local compactness, limit point compactness and sequential compactness; Tychonoff theorem, Stone-Weierstrass theorem.

Hausdorff, regular and normal spaces; Urysohn lemma, The Tietze extension theorem;

compactification; Urysohn's metrization theorem.

Prerequisites: NA

MA509 Statistical Inference (6 Credits)

Order statistics: Distribution of rth order statistics, joint distribution of rth and sth order statistics, distribution of range, sample median and mid-range.

Estimator: Statistic, estimate, estimator, unbiasedness, consistency, strong consistency

efficiency, efficient estimator, sufficient statistics, minimal sufficient statistics, exponential family, completeness, ancillary statistic, Basu's theorem, Fisher information, Cramer-Rao lower bound (CRLB), Bhattacharyya bound, uniformly minimum variance unbiased estimator (UMVUE), Rao-Blackwell theorem, Lehman-Scheffe theorem.

Method of Estimation: Maximum likelihood estimator (MLE), properties of MLE's, limiting distribution of MLE, Method of moments.

Bayesian estimation (Basic): Loss functions, prior and conjugate prior, posterior distribution, Bayes' risk and Bayes' estimator.

Testing of hypothesis: Hypothesis, critical region, p-value, size of test, level of significance, types of errors, power of the test and power function, randomized and nonrandomized test, monotone likelihood ratio (MLR) property, Neyman-Pearson lemma-I and II, most powerful test (MP test), uniformly most powerful test (UMP test), uniformly most powerful unbiased test (UMPU test), Karlin-Rubin theorem, likelihood ratio test.

Interval Estimation: Interval estimator, method of finding interval estimators, pivotal quantity method.

Prerequisites: NA

MA510 Elementary Number Theory (6 Credits)

Preliminaries: Well-Ordering Principle, Mathematical induction, Binomial theorem.

Divisibility theory: Division algorithm, The greatest common divisor and the least common multiple, Euclidean Algorithm, Prime numbers, Prime number theorem (statement only), Fundamental theorem of arithmetic, The linear Diophantine equation in two unknowns, The theory of congruences.

Fermat's theorem, Pseudoprimes, Wilson's Theorem, Euler's generalization of Fermat's theorem, Number Theoretic functions, Primitive roots, The quadratic reciprocity law. Brief introduction to public key cryptography.

Number of special forms: Perfect numbers, Mersenne primes, Fermat numbers, Fibonacci numbers.

Some nonlinear Diophantine equations: The Pythagorean equations, A special case of Fermat's last theorem.

Representation of integers as sums of squares, continued fractions, Pell's equation.

Prerequisites: NA

MA511 Topics in Nonlinear Analysis (6 Credits)

Distribution Theory: Test functions and distributions, Operations on distributions: differentiation, multiplication, convolution, Fourier transform, Schwartz spaces, tempered distributions

Sobolev Spaces: Review of Lebesgue spaces, approximation by smooth functions, extension, embedding and compactness theorems, dual spaces and trace theory

Weak Solutions of boundary value problems: Abstract variational problems, Stampacchia and Lax-Milgram theorems and its applications in elliptic boundary value problems

Prerequisites: Basic Analysis

MA512 Topics in Fixed Point Theory (6 Credits)

Metric Fixed Point Theory: Banach contraction principle and its various applications to integral equations, differential equations and numerical analysis; Some generalizations of Banach contraction principle; Fixed points results in partially ordered metric space and its

applications to matrix quations; Multi-valued maps, examples, Hausdorff metric and Nadler's theorem.

Fixed Points in Topological Spaces: Brouwer's fixed point theorem and applications; Schauder's fixed point theorems and applications to Peano existence theorem, nonexpansive maps, examples, fixed point theorem for non-expansive maps, Kakutani fixed point theorem for mauti-valued maps and its applications, Key-Fan best approximation theorem.

Prerequisites: Basics of Analysis and Topology

MA513 Introduction to Linear Regression and Experimental Design (6 Credits)

Descriptive Statistics, Sampling Distributions, Basic concept of estimation and hypotheses testing.

Simple and multiple linear regression models, estimation, tests and confidence regions for model parameters; model adequacy checking; diagnostics for leverage and influence; Multicollinearity, Polynomial Regression Model.

Analysis of Variance, Complete Randomized Designs, Randomized Block Designs, Factorial experiments.

Prerequisites: Probability and Statistics/ Statistical Inference

MA514 Analytic Number Theory (6 Credits)

Prime numbers, Fundamental theorem of arithmetic, Basic concepts of the theory of congruences.

Arithmetic functions: Basic concepts of arithmetic functions, Dirichlet multiplication, Asymptotic estimates for arithmetic functions.

Some elementary results on the distribution of prime numbers.

Characters of a finite abelian group, Dirichlet's theorem on the primes in an arithmetic progression.

Dirichlet series and Euler products, The Riemann zeta function.

Prime number theorem and its analytic proof.

Prerequisites: Real Analysis, complex analysis algebra basic group theory

MA515 Matrix Analysis (6 Credits)

Review of some basic concepts, Matrices of special types and their properties (Projection and orthogonal projection matrices, Idempotent matrices, Nilpotent matrices, Orthogonal Matrices, etc). Generalized inverses, Moore-Penrose inverse, Quadratic forms, Positive Definite and Semidefinite Matrices, Similar and Equivalence Matrix, Matrix decomposition, Vector, and matrix differentiation, Kronecker Products and the Vee and Vech Operators, Matrix Norm and Sum of Matrices, Canonical forms, Eigenvalues and Eigenvectors, Location and Perturbation of Eigenvalues.

Prerequisites: Linear Algebra I,II/ Linear Algebra

MA600 Analysis (6 Credits)

Metric spaces, open and closed sets, complete metric space, compactness and connectedness,

Continuity of a function, Cantor's intersection theorem, Baire category theorem, uniform continuity, compact metric space, sequences and series of functions, uniform convergence, differentiation, inverse and implicit function theorems, Riemann integration, Lebesgue integration.

Prerequisites: NA

MA601 Numerical Methods and Computing (6 Credits)

Numerical solutions of equations in one variable, interpolation and approximation, numerical differentiation and integration, Numerical solution of ordinary differential equations: Runge-Kutta methods, derivation, error bounds and error estimates, Gauss-Seidel and Gauss-Jacobi iterative methods for solving system of linear algebraic of equations, computing of eigenvalues and eigenvectors. Computer lab by using appropriate software tools like Python, MATLAB etc.

Prerequisites: NA

MA602 Differential Equations (6 Credits)

Picard-Lindelöf theorem for initial value problems, Peano's existence theorem, continuous dependence on initial condition; solutions of linear ordinary differential equations; linear systems.

First order quasi-linear and nonlinear partial differential equation, classification of second order partial differential equation; Solution methods for Laplace's and Poisson's equation; Solution methods for heat equation; Fourier and separation of variable method for heat, Laplace and wave equations.

Prerequisites: NA

MA603 Linear Algebra (6 Credits)

Vector spaces, subspaces, bases and dimensions, linear transformations, matrix representations of linear transformations, range space and null space, the rank-nullity theorem, invertibility; eigenvalues and eigenvectors, annihilating polynomial, the minimal polynomial and the characteristic polynomial, Cayley-Hamilton theorem, invariant subspaces, triangulation, diagonalization; inner product spaces, orthonormal bases, linear functional, self-adjoint, normal and unitary operators.

Prerequisites: NA

MA604 Functional Analysis (6 Credits)

Review of metric spaces, normed linear spaces, Banach spaces, linear maps, boundedness, non-compactness of the unit ball in infinite dimensional normed linear spaces, quotient spaces; Banach-Steinhaus theorem, open mapping theorem and closed graph theorem, Hahn-Banach theorem.

Hilbert Spaces: Bessel's inequality, complete systems, Gram-Schmidt orthogonalization, Parseval's identity, projections, orthogonal decomposition.

Dual spaces, Riesz representation theorem, reflexivity, weak topologies, weak convergence, weak compactness, Banach-Alaoglu theorem.

Prerequisites: NA

MA605 Operations Research (4 Credits)

Linear optimization: Formulation and geometrical ideas of linear programming problems, simplex Method, revised simplex method, duality, sensitivity analysis, transportation and assignment problems, introduction to interior-point methods.

Nonlinear optimization: Method of Lagrange multipliers, KKT conditions, convex optimization, quadratic optimization, numerical methods for constrained optimization, dynamic programming.

Prerequisites: NA

MA606 Partial Differential Equations (6 Credits)

First-order equations, method of characteristics and existence of local solutions; Hamilton• Jacobi equation, Hopf-Lax formula, weak solution of Hamilton-Jacobi equation and its uniqueness; introduction to conservation laws, weak solutions, Rankine-Hugoniot condition, shocks, Lax-Oleinik formula, entropy condition and uniqueness of entropy solution.

Characteristic Manifolds and Cauchy Problem, non-characteristic surfaces, Cauchy-Kowalevski theorem and uniqueness theorem of Holmgren.

Laplace Equation, fundamental solution, harmonic function and its properties; Poissons equation, Dirichlet problem and Greens function; existence of solution of the Dirichlet problem using Perrons method; Introduction to variational method; Heat Equation, fundamental solution and initial-value problem; mean value formula, maximum principle, uniqueness and regularity; nonnegative solutions; Wave Equation, d'Alemberts formula, method of spherical means, Hadamards method of descent, Dumahels principle and Cauchy problem, initial-boundary-value problem.

Prerequisites: NA

MA607 Fourier Analysis (6 Credits)

Convolution, elementary properties of convolutions; The Hardy-Littlewood maximal function, approximations of the identity, weak-type inequality, Marcinkiewicz interpolation theorem, Hardy-Littlewood maximal function and its properties, dyadic maximal function, Calderon• Zygmund theorem, Riesz-Thorin interpolation theorem.

Introduction to Fourier series, basis approximation theorem, Dini's conditions. Introduction to Fourier transform; Plancherel theorem, Wiener-Tauberian theorems, Interpolation of operators, maximal functions, Lebesgue differentiation theorem, Poisson representation of harmonic functions, introduction to singular integral operators.

Prerequisites: NA

MA608 Martingale Theory (6 Credits)

Review of conditional expectation: Conditional expectation and conditional probability, regular conditional distributions, conditional independence. Martingales and Stopping times: Stopping times, random time change, sigma field, martingale property, optional sampling theorem, maximum and upcrossing inequalities, martingale convergence theorem.

Gaussian processes and Brownian motion: Symmetries of Gaussian distribution, existence and path properties of Brownian motion, law of iterated logarithm, Martingale central limit theorem.

Prerequisites: Probability Theory

MA609 Numerical Optimization Techniques (2 Credits)

Numerical optimization techniques: line search methods, gradient methods, Newton's method, conjugate direction methods and quasi-Newton methods.

Prerequisites: NA

MA610 Operator Theory (6 Credits)

Overview of Hahn-Banach theorem, Open mapping theorem, Closed graph theorem, Uniform boundedness principles.

Banach algebras, Gelfand theory, C*-algebras the GNS construction, spectral theorem for normal operators, Fredholm operators. The L-infinity functional calculus for normal operators.

Prerequisites: Some basics of Analysis and Measure Theory

MA611 Stochastic Processes (6 Credits)

Review of random variables and distribution functions, Discrete-time Markov chains: Markov property, class division, hitting time and absorption probabilities, strong Markov property, recurrence and transience, invariant distributions, convergence to equilibrium. Continuous time Markov chains: Q-matrices, embedded Markov chain, Kolmogorov forward and backward equations, classification of states, limit theorems. Poisson Process: its different characterizations, inter-arrival and waiting time distributions, conditional distribution of arrival times. Random walk in 1,2,3-dimension, the Reflection Principle, hitting probabilities of a finite sets, coupling and total variation distance, mixing time.

Prerequisites: Advance knowledge of probability theory (Instructor's consent will be required)

MA612 Set-Valued Analysis (6 Credits)

Definition of Set- Value Maps and Examples; Domain, range and graph of set-valued map; Upper semi-continuity, lower semi-continuity and closed graph of SVM; composition of two SVM and inverse image; some theorems that related continuity and closed graph of SVM; Hausdorff metric and its properties; Existence results for set-valued Variational inequalities and its applications to game theory in particular to Nash equilibrium problems.

Prerequisites: Real Analysis

MA613 Operator Theory II (6 Credits)

Overview of Gelfand theory, C"*-algebras the GNS construction, Spectral theorem for normal operator. Compact Operator, Schatten-p-class operators, Basic van-Neumann algebras, Operator spaces, Contractive and complete contractive homomorphism, Function algebra, Dilation

Prerequisites: Some basic of functional analysis, measure theory, operator theory

MA614 Introductory Additive Number Theory (6 Credits)

Basic number-theoretic concepts. Sumsets of finite sets of integers: Introduction to sumsets, Direct and inverse problems for sum sets, Freiman's inverse theorem (statement only), Applications to the number of sums and products, sumsets and powers of 2, Introduction to subset sums, Direct and inverse problems for subset sums.

Sumsets of sets of congruence classes: Set addition in groups, e-transform, Kemperman transform, Cauchy-Davenport theorem, Pollard's theorem, Erdos-Ginzburg-Zlv theorem, Chevalley-Warning theorem, Vosper's theorem, Freiman-Vosper theorem (statement only). Restricted sums of sets of congruence classes: Erdds-Heilbronn conjecture and Dias da Silva-Hamidoune theorem, Polynomial method in additive number theory: Proofs of Cauchy-Davenport theorem, Erdos-Heilbronn conjecture and its h-fold generalization.

Sumsets in groups: Periodic subset of a group, Kneser's addition theorem, Some applications of Kneser's theorem.

Prerequisites: Undergraduate courses in Abstract Algebra, Linear Algebra.

MA615 Critical Point Theory (6 Credits)

A review of Sobolev spaces and differential calculus for real functionals on a Banach space, critical points via minimization, pseudo gradient field, deformation theorems, minimax theorems and applications: generalized mountain pass and saddle point theorems, constrained minimization problems, Ekeland variational principle, problems with lack of compactness.

Prerequisites: Basic functional analysis

MA616 Algebraic Number Theory (6 Credits)

1. Historical Background, algebraic numbers, algebraic integers and their properties, Characteristic and minimal polynomial of an element- relative to a finite extension, Equivalent definitions of norm and trace.
2. Integral bases, discriminant, Stickelberger's theorem, Brille's theorem, description of integral basis of quadratic, pure cubic number fields and cyclotomic fields.
3. Ideals in the ring of algebraic integers and their norm, factorization of ideals into prime ideals, generalised Fermat's theorem, Euler's theorem.
4. Ramification index and Residual degree, Dedekind's theorem for decomposition of rational primes in algebraic number fields and its application, splitting of rational primes in quadratic and cyclotomic fields, Finiteness of ramified primes.
5. Factorisation into irreducible elements, Dirichlet's theorem on units, regulator of an algebraic number fields, explicit computation of fundamental units in real quadratic fields.

Prerequisites: Basic knowledge of Abstract Algebra.

MA617 Statistical Decision Theory (6 Credits)

Group of Transformations; Principle of invariance, Location, Scale and Affine Equivariant estimators. General Principle of equivariance; Minimum risk equivariant estimators under location scale and location-scale families; Pitman Estimator; Bayesian estimation; prior distributions; posterior distribution; Bayes estimators; limit of Bayes estimators; hierarchical Bayes estimators; Generalized Bayes estimators; Empirical Bayes Estimator, James-Stein estimator, Minimax estimators and their relationships with Bayes estimators; admissibility; Review of hypotheses testing problem. Invariance in hypothesis testing; Unbiased test and its

Applications to Normal Distributions; Confidence Intervals; Equivariant Confidence Sets, Bayesian Confidence Sets.

Prerequisites: Statistical Inference

MA618 Introduction to Spectral Theory (6 Credits)

Introduction: Origin - spectrum and invertibility.
Banach Algebra: Ideals & quotients - spectrum of an element of a Banach algebra - spectral radius - Reisz functional calculus - dependence of the spectrum on the algebra.
Spectral Representation: Spectrum and resolvent - various sub-divisions of spectrum - spectral projection - spectral measure - spectral representation theorem of compact operators and self-adjoint operators.
Compact Perturbation & Fredholm theory: Calkin algebra - Fredholm operators Fredholm index - Riesz theory of compact operators - Fredholm alternative - essential spectrum - further analysis of spectrum.
Spectral properties of unbounded linear operators: unbounded linear operators and Hilbert adjoint - symmetric and self-adjoint linear operators - spectral properties of self-adjoint linear operators - multiplication operator - differentiotion operator - applications in quantum physics.

Prerequisites: Functional Analysis or Related Areas (MA604)

MA619 Advanced Algebraic Number Theory (6 Credits)

Prime ideal decomposition in relative extensions: Relative Ramification Index and Residual Degree - Splitting of Prime Ideals in Galois Extensions - Norm of an Ideal in Relative Extensions - The Fundamental Equality in Relative Extensions.
Relative Discriminant and Dedekind's theorem on ramified primes: Notions of Relative Different and Relative Discriminant - Properties of Relative Different and Relative Discriminant - Dedekind's Theorem on Ramified Primes.
Class Group and Class Number: Finiteness of Class Number - Computation of Class Number - Hermite's Theorem on Discriminant.
Dirichlet's Class Number Formula and its Applications: Dirichlet's Class Number Formula and Ideal Theorem - Derivation of Dirichlet's Class Number Formula - Applications of Dirichlet's Class Number Formula.
Simplified Class Number Formula for Cyclotomic, Quadratic Fields: Numerical Characters and l-functions - Simplification of Class Number Formula for Cyclotomic Fields - Dirichlet's Theorem for Primes in Arithmetic Progressions - Simplified Class Number Formula for Quadratic Fields.

Prerequisites: Basic Knowledge of Algebra and Number Theory (MA616)

MA699 Thesis (variable Credits)

Students registering for this course are associated with a supervisor and have to carry out research work. Student will be evaluated for the program in research at the end of semester.

Prerequisites: NA

MA795 Candidacy (0 Credit)

The objective of this candidacy is to evaluate the candidate's ability to carry out research and shall include the evaluation of the knowledge breadth of the student, including the research comprehension.

Prerequisites: Student must have completed the course credit requirement for the program registered for.

MA798 Independent Study (variable Credits)

Students registering for this course are expected to get versed in a particular topic allotted by the course instructor. The topic and the credits are assigned by the course instructor. There will not be any regular lecture delivered for this course type.

Prerequisites: The course is available only to PG students.

MA799 Thesis (variable Credits)

Students registering for this course are associated with a supervisor and have to carry out research work. Student will be evaluated for the program in research at the end of semester.

Prerequisites: Student must have cleared candidacy.

Courses in Mechanical Engineering

ME102 Engineering and Machine Drawing (3 Credits)

Introduction to sketching; Principal views; Principles of dimensioning; Introduction to computer aided graphics; Missing view, sectional view and assembly drawings; Pictorial representation, isometric drawing, Perspective drawing; Lines, planes, auxiliary view, Relationship between lines and planes; Intersections and development of lateral surfaces; Conceptual design, embodiment design, designing to standard, machine drawing, dimensioning as per standards, fits and tolerances, machine elements, assembly drawing, geometrical modelling, and use of CAD software for modelling and animation.

Prerequisites: NA

ME110 Machine Drawing (3 Credits)

Conceptual design, embodiment design, designing to standard, machine drawing, dimensioning as per standards, fits and tolerances, machine elements, assembly drawing, geometrical modeling, and use of CAD software for modeling and animation.

Prerequisites: NA

ME111 Thermodynamics (6 Credits)

Introductory concepts and definitions; First law of thermodynamic; Quasi-static and reversible processes; Adiabatic changes; Carnot cycle; Second law of thermodynamics; heat engines and refrigerators, absolute temperature scale; Entropy and the Clausius inequality, second law in terms of entropy, the Gibbs equation, entropy for ideal gases, entropy change for reversible and irreversible processes, Availability; Thermodynamics property relations; Properties of pure substances; Thermodynamics cycles.

Prerequisites: NA

ME151 Fundamentals of Metallurgy (3 Credits)

Structure of metals: Interatomic bonding - Crystal system - Unit cells - Point coordinates - Crystallographic directions - Crystallographic planes - Millers indices - Bravais lattice - Allotropy.
Material properties: Theoretical strength - Defects in crystals - Slip and Twin -Anisotropy.
Phase Diagram: Formulation - Equilibrium structure - Fully soluble system - Partially soluble system - Gibbs phase-rule - Hardening and softening thermal treatments - m diagrams - CCC diagrams.

Prerequisites: NA

ME201 Design and analysis experiments (2 Credits)

Fundamental of statistics, Basics of experimental design, Hypothesis testing, Analysis of variance (ANOVA), Regression analysis, Taguchi method, Introduction to factorial design and Response surface methodology.

Prerequisites: NA

ME212 Fluid Mechanics (6 Credits)

Introduction and fundamental Concepts; Fluid statics; Kinematics of fluid; Governing equations and analysis of finite control volume; Applications of governing equations of motion and mechanical energy; Principles of physical similarity and dimensional analysis, flow of ideal fluids; Viscous incompressible flows; Laminar boundary layers; Turbulent flow; Applications of viscous flow through pipes; compressible flows.

Prerequisites: NA

ME213 Heat and Mass Transfer (6 Credits)

Introduction, rate equation and conservation of energy equations, modes of heat transfer; Conduction: 1D steady and unsteady state heat conduction, heat transfer of extended surfaces;

Convection: governing equations, dimensional analysis, boundary layers; Forced convection: external and internal flows; Natural and Mixed convection; Design of heat exchangers: LMTD and NTU methods; Radiation: Processes and properties; Black and real body radiation; view factor and radiation exchanges between surfaces in an enclosure; concept of mass transfer.

Prerequisites: NA

ME229 Thermodynamics II (4 Credits)

Statements of the second law, heat engines and refrigerators, absolute temperature scale; Entropy: theoretical development, second law in terms of entropy, the Gibbs equation, entropy for ideal gases, entropy change for reversible and irreversible processes, tabulation of entropy, adiabatic reversible processes for ideal gases, entropy of mixing, probabilistic approach; Second law analysis for control volumes: irreversible entropy production; Cycles: Otto, Diesel, Rankine, Brayton, refrigeration; Exergy; Maxwell relations, heat capacity, real gas behavior and non-ideal equations of state; Thermochemistry - Application of first and second laws to chemical reactions, Calorimetry.

Prerequisites: NA

ME230 Fluid Mechanics II (3 Credits)

Differential analysis to fluid flow: Conservation of Mass - Coordinate systems, Kinematics - Translation, Rotation, Deformation, derivation of Governing equations of fluid flows – continuity, Euler equations, Potential flows - Bernoulli equation and applications to external aerodynamics, Navier-Stokes equations, Non-dimensional analysis; Exact solutions of Navier-Stokes equations; Internal flows; External flows - Prandtl's Boundary layer theory - flow over a flat plate, concept of similarity; Approximate methods - von Karman Integral analysis; (Thwaites method); Flow separation; Brief introduction to turbulence - characteristics of turbulence, drag crisis.

Prerequisites: NA

ME231 Solid Mechanics-I (6 Credits)

Fundamental principles of mechanics, Fundamental of Mechanics of Deformable solids - Introduction, analysis of axial and shear loaded components. Statically determinate and indeterminate problems. Castigliano's theorem. Beams - shear force and bending moment

diagrams. Stress, strain, and their relationships. Thermal stress, fatigue and creep. Mohr circle. Stresses in beams. Torsion. Thick cylinders and rotating.

Prerequisites: NA

ME232 Dynamics (6 Credits)

Kinematics of particles, Rectilinear motion of particles, curvilinear motion of particles; Kinetics of particles; Kinetics of system of particles, Plane kinematics of rigid bodies; Plane kinetics of rigid bodies, energy and momentum methods, Kinetics and Kinematics of rigid bodies in three dimensions; Introduction to mechanical Vibrations.

Prerequisites: NA

ME250 Solid Mechanics II (4 Credits)

Deflections of beams, energy methods, analysis of stress and strain, stress transformation, applications of plane stress, pressure vessel, column buckling, and statically indeterminate structures.

Prerequisites: NA

ME251 Manufacturing Science I (6 Credits)

Introduction to manufacturing; Engineering Materials; Casting/Solidification; Welding; Deformation processes: Extrusion (direct and indirect), Rolling, Forging (open and closed die), Wire drawing, Sheet metal forming. Powder metallurgy: Introduction, Powder production, Compaction, and Sintering, Engineering stress-strain curve. Plastic injection molding: Flow forming of plastic components.

Prerequisites: NA

ME270 Manufacturing Science I (4 Credits)

Introduction to Manufacturing and its evolution, Net and near-net shape manufacturing; Metal Casting: Solidification of Alloys and its mechanism, Gating System Design and Estimation of Solidification time, Riser Design and Riser Placement, Process Variations, Defects and Product Design; Metal Forming: Mechanism of plastic deformation, fundamentals of plasticity, Introduction to Force equilibrium method, State of Stress and boundary conditions in Upsetting/forging, Rolling, Wire and tube drawing, Extrusion and Deep Drawing, Defects, Load estimation for one plane strain and one axi-symmetric bulk deformation processes, Analysis of Deep Drawing and Bending, Introduction to High velocity forming processes; Powder Processing (Metals and Ceramics), Polymer Part Manufacturing, Introduction and properties of polymer melts and Visco-elasticity, Processing of Thermoplastics (Extrusion, Injection Molding, Blow Molding, Rotational Molding) and Thermosets (compression and transfer molding), Tool and product design principles; Rapid Manufacturing: Need for RP/RT/RM, Introduction to Processes for Prototyping, Tooling and Manufacturing; Joining and Welding: Introduction, Solid State and Fusion Joining, Brazing and Soldering, Mechanical and Adhesive Joining, Metal and nonmetal joining; Metrology: Tolerancing (Dimensional and Geometric) principles and their measurements (Geometrical tolerances using point data), Interferometry - principles, flatness testing using optical flat, optical interferometers, Moire fringe system measurements.

Prerequisites: NA

ME314 Thermal and Fluid Engineering (6 Credits)

Overview of basic thermodynamics: Thermodynamic systems, processes, properties; Zeroth, First, Second, third law of thermodynamics, availability. Thermodynamic cycles: Pure substances, Rankine cycle, Otto, Diesel, Dual cycles, Brayton cycles, Refrigeration cycles.

Fluid properties: continuum, density, viscosity, surface tension, velocity, pressure, temperature; Fluid Statics: Hydrostatics, Fluid forces on planes and curved surfaces, submerged and floating bodies, Buoyancy and stability; Types of fluid flow: viscous vs inviscid flows, laminar vs turbulent flows, compressible vs incompressible flows; Non-dimensional analysis; Energy equations and its applications: Bernoulli equation, venturi, orifices, pitot tube etc; External and internal flows: flow over flat plate, cylinder, flow in a pipes and channels; Basics of hydraulic machines: rotary and reciprocating.

Overview of basic modes of heat transfer; Heat conduction: steady state heat conduction in plane and composite walls, critical thickness of insulation, lumped heat conduction, extended surfaces; Heat convection: Forced and free convection, internal and external flows; Heat exchangers: types, concept of LMTD, effectiveness; Radiation heat transfer: basic laws, radiation heat exchange between surfaces.

Prerequisites: NA

ME331 Solid Mechanics-II (6 Credits)

Introduction. Torsion of thin cylinders. Unsymmetrical Bending. Shear center. Deflection of beams - double integration, superposition, moment area and energy methods. Castigliano's theorem. Principle of virtual work. Statically inderminate problems. Continuous beams. Deflection in the presence of axial load. Buckling - Euler, Secant and Rankine - Gordon Formulae. Bending of Curved bars.

Prerequisites: ME231

ME333 Theory of Machines and Mechanism (6 Credits)

Kinematic pairs, diagrams and inversion; Mobility and range of movement; Displacement, velocity and acceleration; Analysis of planar linkages; Dimensional synthesis for motion, path and function generation; Gears and gear trains; Dynamic force analysis; Inertia forces and balancing for rotating and reciprocating machines; Cam mechanisms, Cam profile synthesis; Flywheels; Governors; Gyroscopes;

Prerequisites: NA

ME334 Design of Machine Elements (6 Credits)

Introduction to design of systems and machine elements; Modes of failure, strength, stiffness and stability; Failure theories; Fatigue failure; Probabilistic approach to design; Design of joints; Design of spring; Design of Spur and Helical gear sets; Design of belt and chain drives; Analysis of clutches and brakes; Sliding and rolling contact bearings; Design of shafts; Analysis and application of coupling.

Prerequisites: NA

ME351 Metrology, Measurement and Instrumentation (4 Credits)

Fundamentals of measurement, Line and end standards, types of errors, Geometric dimensioning and tolerance (GD&T), types of fits, GO and NO GO gauges.

Static and dynamic characteristic of instrument, measurement of different geometric forms (flatness, circularity etc.), Coordinate measuring machine, Measurement of temperature, pressure, forces, torque, strain, calibration of instrument.

Prerequisites: NA

ME352 Manufacturing Science II (6 Credits)

Machining; Plastic Deformation, Mechanism of Plastic Deformation; Types of machining processes; Chip formation; Cutting; Tool Geometry; Multiple point cutting tools; Mechanics of Metal Cutting, Merchant's Circle Diagram; Friction in Metal Cutting; Mechanism of Oblique cutting; Rake angles in oblique cutting; velocity relationship and Force relationships in oblique cutting; General classification of unconventional machining, chemical machining, electric-discharge machining, Abrasive Jet and Ultrasonic Machining, electron beam machining, laser beam machining, ion beam machining, plasma arc machining; Comparative evaluation of different processes.

Prerequisites: NA

ME353 Total Quality Management (3 Credits)

Introduction, Historical Review, TQM Principles, Continuous Process Improvement - Juran Trilogy, PDSA Cycle, Kaizen, Supplier Partnership - Partnering, TQM Tools: Benchmarking - Reasons to Benchmark, Benchmarking Process, Quality Function Deployment (QFD) House of Quality, QFD

Process, Benefits, Taguchi Quality Loss Function, Total Productive Maintenance (TPM) - Concept, Improvement Needs, FMEA - Stages of FMEA, The seven tools of quality, Process capability, Concept of six sigma, New seven management tools, Case studies. Quality Systems: Need for ISO 9000 and Other Quality Systems, ISO 9000:2000 Quality System - Elements, Implementation of Quality System, Documentation, Quality Auditing, QS 9000, ISO 14000 - Concept, Requirements and Benefits, Case Studies.

The main aim of this course is to develop an understanding on quality management

philosophies and frameworks.

Prerequisites: NA

ME355 Mechanical Behavior of Material (4 Credits)

Introduction to deformation-Crystallaography-Elastic deformation-Plastic deformation-Stress strain relationship-Effect of strain rate-Temperature in deformation-Various evaluation techniques.

Prerequisites: ME231

ME371 Mechanical Engineering Lab-I (3 Credits)

1. experiments to demonstrate/validate principles of solids mechanics, dynamics and fluid mechanics
2. experiments related to measurement of stress, strain, deflection, velocity, acceleration,

forces, pressure, flow, etc.

Prerequisites: ME231, ME232, ME212

ME372 Mechanical Engineering Labs-II (3 Credits)

1. experiments to demonstrate/validate principals of thermal engineering and manufacturing science
2. experiments to demonstrate several machining process
3. experiments related to measurement and characterization techniques in manufacturing science and thermal engineering

Prerequisites: ME251, ME213

ME380 Manufacturing Lab (2 Credits)

Job preparation using CNC machining, Form measurement; Digitization using 3D scanner, surface roughness testing. Cutting force measurement using dynamometer. Sample preparation and characterization using Optical Microscope. Metrology.

Prerequisites: NA

ME403 Operation Research (4 Credits)

Linear Programming (Simplex Method, Big-M method), Transportation and assignment model, Sequencing, Inventory management, Queuing theory, CPM and PERT, Investment and break even analysis, Forecasting.

Prerequisites: NA

ME413 Refrigeration and Air-Conditioning (6 Credits)

Introduction and applications, Vapor compression systems: Ideal and real cycle analyses, Refrigerants and their properties, energy efficiency and environmental considerations. Advanced vapor compression cycles. Refrigeration system components: condensers, evaporators, compressors and expansion devices. Vapor absorption and gas cycle refrigeration.

Human Physiology and thermal comfort. Factors influencing thermal comfort. Introduction to air-conditioning, Properties of moist air, Psychrometric chart, Psychrometric Processes - heating, humidification, cooling and dehumidification etc. Cooling and heating load calculations. Room air distribution principles. Design of air duct systems. Indoor air quality. Ventilation. Various types of air conditioning systems. Cooling, dehumidification and humidification equipment. Temperature, pressure and humidity controllers. Various types of controls and control strategies.

Prerequisites: ME111, ME213

ME414 Introduction to Steam and Hydraulic Turbines (2 Credits)

Steam turbins:

Construction and working of steam turbines, Impulse and reaction inlet and outlet velocity

diagram. Work output and efficiencies. Pressure and velocity compounding regenerative feed heating cycle reheat cycle, reheat factor, governing of turbine, back pressure and pass out turbine.

Dynamic action of fluid jet:

Impact of fluid jet on fixed and moving flat places, impact of jet on fixed and moving curved vanes, flow over radial vanes, jet propulsions, Euler's fundamental equation, degree of reaction.

Hydraulic turbines:

Introduction, classification, impulse turbine, construction details, velocity triangles, power and efficiency calculations, reaction turbines; constructional details, working principle, velocity triangles, power and efficiency calculations, draft tube, cavitation, governing

Prerequisites: ME111, ME212

ME415 Introduction to Turbomachines (6 Credits)

Definition and Classification of turbomachines - Specific Work - T-s and h-s Diagram - Incompressible and compressible flow - Losses - Total-to-Total efficiency - Total-to-Static efficiency - Effect of reheat and preheat factor. Degree of reaction. Energy transfer - Euler's equation, velocity triangles.

Dimensional analysis, Dimensionless parameters and their physical significance, specific speed, Hydraulic Pumps: Centrifugal Pumps - Some definitions - Pump output and Efficiencies - Effect of Vane angle - Cavitation - Pump Characteristics - Multistage pumps.

Hydraulic Turbines: Classification of hydraulic turbines - Velocity triangles. Efficiencies of draft

tubes - Hydraulic turbine characteristics. Francis and Kaplan turbines - Velocity triangles - Efficiencies of Draft tubes - Turbine characteristics.

Elementary cascade theory, cascade nomenclature, compressor cascade, turbine cascade, cascade efficiency. Dimensional analysis of compressible flow machines, stalling and surging.

Centrifugal Compressors: Constructional details - Stage Pressure rise - Stage Pressure Coefficient - Stage Efficiency - Degree of Reaction - Various Slip factors - Introduction to Fans

and Blowers, Working principle, Fan laws, Performance Characteristics.

Axial flow Compressors: general expression for degree of reaction; velocity triangles for different values of degree of reaction, Blade loading and flow coefficient, Static pressure rise,

Work done factor.

Steam and Gas Turbines: Axial turbine stages - Stage velocity triangles - Work - Single stage impulse turbine - Speed ratio - Maximum Utilization Factor - Compounding of Turbines and its

types, Degree of Reaction - Reaction Stages. Inward Flow radial turbine stages (IFR) - Working

principle and Performance Characteristics

Prerequisites: ME111, ME212

ME416 Power Plant Engineering (6 Credits)

Economics of Power Generation: Introduction, Power plant economics, Types of power plants

Steam Power Plants: Introduction, Economics of Power Generation, Reheating and regeneration, Feedwater heaters, Supercritical pressure cycle, Deaerator, Binary vapour cycle, Combined cycle plants, Coal, Coal analysis, Combustion reactions, Energy balance of steam generator

Steam Generators, Steam Turbines, Condenser

Introduction, Basic types of steam generators, Fire tube and water tube boilers, Ash handling

system, Feedwater treatment, Steam turbines, Condenser, Cooling towers

Diesel Engine and Gas Turbine Power Plants

Introduction, Combustion in a CI engine, Performance characteristics, Supercharging, Layout of a diesel engine power plant, Gas turbine power plant, Components of gas turbine plant, gas turbine fuels, Gas turbine Materials

Nuclear and Hydroelectric Power Plants

Nuclear fusion and fission, Chain reaction, Nuclear fuels, Components of nuclear reactor, Classification of reactors, Nuclear waste and its disposal, Advantages and disadvantages of Hydroelectric power plant, Classification of hydroelectric power plants, Pelton, Francis turbines and Kaplan turbines

Non-conventional and Renewable Power Generation

Introduction, Renewable energy sources potential, Solar power plants, Thermal energy, Wind energy, Wind power plant, Waste to power generation, Geothermal energy.

Prerequisites: NA

ME472 Heat Transfer Labs (6 Credits)

Temperature measurement and calibration; Shell and tube heat exchanger in parallel and counter flow configurations; Determination of emissivity and Stefan-Boltzmann constant; Measurement of convective heat transfer coefficient; Free and forced convection.

Prerequisites: NA

ME499 Thesis (Variable Credits)

Students registering for this course are associated with a supervisor and have to carry out research work. Student will be evaluated for the program in research at the end of semester.

Prerequisites: This course is only for BTech Honours student.

ME501 Applied Numerical Methods (6 Credits)

Introduction to Mathematical Modelling; Taylor and Fourier series expansion; Root finding; Interpolation, splines, extrapolation; Regression and curve fitting; Solution of simultaneous linear algebraic systems; nonlinear algebraic equations; Eigenvalues and eigenvectors; Solution of simultaneous nonlinear algebraic systems; Numerical integration, Simpson's rule, Gaussian quadrature; Solution of ODE: R. K. Methods; Predictor-Corrector methods; boundary value problems; Systems of ODEs; convergence and error studies; Linear PDEs by finite differences.

Prerequisites: IC104, IC152

ME502 Advanced Engineering Mathematics (6 Credits)

Differential Equations: Review of first-order and second and higher order differential equations; System of differential equations; Series solutions, Special functions; Laplace transforms, Numerical methods for differential equations

Linear Algebra: Review of Matrix, Vectors, Determinants, Linear systems of equations, Eigen values, Eigen vectors, Vector differential and Integral calculus; Numerical methods in Linear algebra

Fourier Analysis and Partial Differential Equations: Fourier Series, Integrals and Fourier Transforms, Partial Differential equations

Prerequisites: NA

ME512 Advanced Fluid Mechanics (6 Credits)

Revisiting some preliminary concepts of fluid mechanics: fluid kinematics, dynamics of inviscid flow, Reynolds transport theorem; Dynamics of viscous flows: Navier-Stokes equation; Exact solutions of Navier-Stokes equation; Boundary layer theory; Inviscid incompressible flow: potential flows and flow past immersed bodies; Turbulent flow; compressible flow.

Prerequisites: NA

ME513 Convective Heat Transfer (6 Credits)

Overview of continuity and momentum equations; Derivation of energy equation; Similarity solutions for laminar external flows. Laminar internal flows; Transition flow - Heat transfer in transition flow; Turbulent flow - Reynolds averaged equations of motion, Averaged energy equations; Turbulent flow and heat transfer over a flat plate; Turbulent flow and heat transfer in pipes and channels; Laminar and turbulent natural convection - laminar and turbulent mixed convection; Pool boiling-nucleate boiling-film boiling; flow boiling-condensation; dropwise condensation; film condensation; Convective heat transfer with nanofluids; Combined convection and radiation; Double diffusive convection

Prerequisites: ME212, ME213

ME514 Internal Combustion Engines Fundamental (6 Credits)

Engine classifications; SI and CI engine principle and operation; Engine performance parameters; Rating of SI and CI engine fuels; Carburetion; Mechanical injection system; Electronic injection systems; Multi port fuel injection systems; Common rail diesel injection; Ignition; Mixture formation; Combustion in SI engines; Combustion in CI engines; Lubrication systems; Cooling system; Pollutants formation and their control; Nitrogen oxides, Carbon monoxide, Unburned hydrocarbons, Particulate formation; In-cylinder and after treatment techniques for emission reduction; NOx absorber; DOC and DPF; Engine performance calculations; Supercharging and turbo-charging.

Prerequisites: NA

ME515 Engine Management Systems (6 Credits)

History and Introduction: Evolution of diesel and gasoline engines, Engine management system for
internal combustion engines.
Engine Electronics: Piston displacement and speed sensing, Measurement of pressure, Temperature measurement, Intake air flow measurement
Gasoline engine management: Cylinder charge control systems, Manifold fuel injection, Gasoline
direct injection, Operation of gasoline engine on natural gas, Ignition system, Inductive ignition systems, Different types of sensors such as temperature sensors, Engine speed sensors, Hot film air mass sensors, Piezoelectric knock sensor, High pressure sensor, Lambda sensor, Electronic control unit, Operating conditions.

Diesel engine management: Cylinder charge control systems, Principles of diesel fuel injection,
Mixture distribution, Diesel fuel injection systems, Single plunger fuel injection pumps, Unit injector
systems and Unit pump systems, Common rail systems, Injection nozzles, Minimizing emissions

inside the engine, Electronic diesel control (EDC), Electronic control unit (ECU).

Prerequisites: ME514

ME516 Alternative fuels (4 Credits)

Combustion and Fuels: Flame propagation, Fuel spray pattern, Stratification, Combustion process in SI and CI engines. Liquid Alternative Fuels: Straight vegetable oils, Biodiesels, Emulsified Fuels, HVO, Methanol, Ethanol and higher versions of alcohols. Gaseous alternative fuels: Hydrogen, Liquefied petroleum gas, Di-methyl ether, Hythane. Modern developments in IC Engines such as EGR, MPFI, GDI, HCCI and Turbo-charging, Optical measurement techniques and tools, Pollution monitoring instruments and techniques, Non-Dispersive Infra-Red (NDIR) detectors, The flame ionisation detector (FID), chemiluminescence method for NOx measurement, Engine particle number emission, dilution and measurement. Principle and working of DOC, DPF, SCR and LNT.

Prerequisites: ME514

ME517 Building Environment and Energy Conservation (3 Credits)

Indoor environment - standards and recommendations; Heat loss and heat gains in buildings; Urban heat island effect; Energy Use and Thermal Comfort in Buildings; HVAC systems (performance and efficiency); Building heating and cooling (using conventional & renewable energy); Energy efficiency in district cooling/heating system; Hybrid air-conditioning systems (performance and efficiency); Thermal storage systems integrated in the building envelope.

Indian climate map; Energy performance of Indian buildings; Integrated design process for energy efficient buildings; Passive building design Strategies: Building orientation, sun path, sun exposure, daylight and building natural ventilation, Indoor air quality, building envelope, building thermal insulation, single and double glazing windows, window location and solar protection; Building energy codes - Energy Conservation Building Code (ECBC); Energy Performance Index (EPI); Building rating; Green buildings.

Energy-efficient strategies to maintain thermal comfort; Personal cooling and heating systems; Local body cooling.

Prerequisites: ME213, ME413

ME518 Human Body Thermoregulation & Bio-heat Transfer (3 Credits)

Introduction to human body thermoregulation; Metabolism; Convection over body surface, sweating, respiration; Heat transfer to blood vessels; Body heat balance; Hypothalamus; Maintaining body temperatures; Cold thermoreceptors and heat receptors; Body temperature measurement (mean skin temperature, mean torso temperature and core temperature); Temperature induced dynamic change of blood flow (Vasodilation and Vasoconstriction); Body heat storage; thermal comfort; Cold-spell and heat wave conditions; Hypothermia and hyperthermia; fever; human-clothing interaction, Clothing thermal comfort; Fabric properties

affecting thermal comfort; Thermal comfort evaluation - Thermal manikins and human trials. Thermo-regulation models; Bio-heat transfer models; Application of bioheat transfer - Detection of breast cancer, Tumor thermal treatment, Cryobiology, Determination of degree of skin burn.

Prerequisites: ME212, ME213

ME531 Advanced Mechanics of Solids (6 Credits)

Review of strength of Materials and its limitations. Mathematical Preliminaries; Deformation and Strains; Stress and equilibrium; Cauchy's principle; Constitutive law, Navier's equations, compatibility; Formulation of boundary value problems, Plane Problems; Different approach to solve plane problems with examples (for e.g. Stress function approach, Series solutions, Fourier transform methods); 3D problems by Potential methods, Energy methods and Problems.

Prerequisites: NA

ME535 Theory of Elasticity (6 Credits)

Review of the Field Equations of Linear Elasticity: Kinematics and Kinetics of deformable solids, Constitutive models for linear elastic materials; Theorems of linear elasticity; Two dimensional formulation; Two dimensional boundary values problems; Complex variable methods. Three dimensional boundary value problems; Energy Theorems and Applications; Anisotropic elasticity.

Prerequisites: ME231, ME531

ME551 Advanced Manufacturing Process (6 Credits)

Modern Machining Processes: Electro Discharge Machining (EDM), Processes mechanism of material removal, parameters effects EDM & application, Electrical Discharge Grinding(EDG), Traveling Wire EDM, Electrochemical Machining (ECM), Processes, Mechanism of material removal, Tool design, Parameters affecting ECM , Applications, Electro-chemical Honing(ECH), Electrochemical Debarring (ECD), Electrochemical Grinding(ECG), Electrochemical Discharge Grinding, Chemical Machining, Ultrasonic Machining, Cutting Tool System Design, Mechanism of cutting, Parameters affects USM applications, Abrasive Jet Machining, Variables of AJM, Nozzle Design, Laser Beam Machining, Thermal and Non-thermal analysis, and applications, Electron – Beam Machining and its mechanism, Applications, Plasma arc machining, Equipment, Arc transfer mechanism, Metallurgical efforts, Safety precautions and applications, Plasma are surfacing and plasma Arc Springing, Iron Beam machining and water Jet Machining. High Energy rate forming processes, Advanced Welding Techniques, Additive Manufacturing.

Prerequisites: NA

ME552 Knowledge Base Systems (3 Credits)

Introduction to knowledge base system/Expert system, Importance of expert system, Components of expert system.

Conventional optimisation tools, Genetic algorithm (Basic concepts; Population; Chromosomes; Operators), Fuzzy Set Theory, Fuzzy Logic Controllers (FLC), Neural Network

(NN) Controllers - back propagation network. Combined techniques of soft computing - GA• FLC, GANN, NN-FLC, GA-FLC-NN.

Prerequisites: NA

ME553 Advanced Materials and Processing (3 Credits)

Tools for characterization: Metallurgical sample preparation technique - Spectroscopies - Microscopies – Diffraction analysis.

Role of dislocation: Strengthening mechanisms - Softening mechanisms, structure-property correlationship.

Materials of importance: Special ferrous alloys - Important non-ferrous alloys - Special class of structural materials (non-alloy); Composites.

Processing: Need -Thermo-mechanical processing - Special Processing techniques: Coating, Surface treatment, Additive Manufacturing.

Prerequisites: ME559

ME554 Sensors in Manufacturing (3 Credits)

Importance of sensors-Active and passive sensors-source of sensing: electrical, optical, acoustic, pneumatic, magnetic-sensors in condition monitoring-Sensors in automation.

Prerequisites: NA

ME555 The Science and Technology of Metal Forming (6 Credits)

Introduction: Metal forming processes, definition, advantages, disadvantages, forming equipment Plasticity theory: stress-strain relation, strain• displacement, incompressibility, strain compatibility, yield criteria, flow rule Fundamentals: slip lines field, upper bound and lower bound theorem, slab analysis. Bulk Forming Processes: forging; extrusion, wire and tube drawing, rolling; process description and application of theory. Sheet Forming Processes: blanking, deep drawing, stretch forming, bending. Advanced techniques: numerical approaches in metal forming.

Prerequisites: NA

ME556 Fluid Power Systems (4 Credits)

Fundamentals of Fluid Power - Fluid Properties - Pneumatic and Hydraulic components: symbols and their usage - Fluid power systems as a tool for automation - Predicting Performance Through Simulation - Advanced Components and Systems.

Prerequisites: Fundamental course on Fluid Mechanics

ME557 Laser Material Processing (6 Credits)

Introduction to laser, laser properties, advantages and disadvantages, application; Working principle of different industrial laser, C02 Laser, Nd-YAG laser, Diode laser, Excimer laser, Fiber laser etc. Laser material processing, cutting, drilling, welding, micro-machining, surface treatment, forming, cladding etc. Application of laser in 30 printing, selective laser sintering, laser melting, direct metal deposition, comparison of laser based additive manufacturing with other additive manufacturing process. Laser safety

Prerequisites: NA

ME558 Surface Engineering (6 Credits)

1. Introduction to surface engineering - Concept and importance, Surface Degradation: Causes, types, and consequences of surface degradation. classification of surface modification techniques, advantages, and their limitations.
2. Materials for Surface Engineering: Selection of materials for engineering the surfaces for specific applications, structure and property relationship of coatings system.
3. Conventional surface engineering practices like pickling, grinding, buffing etc., Conventional heat treatment processes. surface modification of ferrous and non-ferrous materials like nitriding, cyaniding, aluminizing etc.
4. Vapour deposition processes: Chemical Vapour Deposition of different types of coatings. Vacuum Evaporation Deposition, Cathodic Arc Evaporation Deposition, Sputtering and its advancements)
5. Thermal Spraying methods: Classifications, Flame and plasma spraying, HVOF, cold spray techniques.
6. Electroplating, Electroless coating, Laser, Electron beam and Microwave assisted Surface Engineering, Friction Surfacing and Friction stir Processing.
7. Physical Characterization: Microstructure, Surface morphology, Phase analysis, Determination of Crystallite size.
8. Mechanical Characterization: Determination of thickness of coating, Coating hardness, Adhesion of surface coating, Surface roughness.
9. Performance evaluation of coatings: Friction and wear performance, Evaluation of corrosion resistance, Assessment of oxidation resistance, Applications of tribological coatings, Performance of cutting tool coatings: Few case studies using hard and soft coatings, HFCVD Diamond coated tool.

Prerequisites: NA

ME559 Mechanical Behaviour of Materials (3 Credits)

Introduction: Crystals - lattice - slip systems -Theoretical strength - defects - stress-strain curve. Deformation: Modes of deformation - deformation mechanisms -Anisotropy. Material testing: Common testing methods - Role of parameters: strain, strain-rate, temperature - cyclic loading - time-dependent deformation - Environmental Effects.

Prerequisites: Fundamental of materials.

ME599 Thesis (Variable Credits)

Students registering for this course are associated with a supervisor and have to carry out research work. Student will be evaluated for the program in research at the end of semester.

Prerequisites: This course is only for MTech student.

ME601 Applied Numerical Methods (6 Credits)

Introduction to Mathematical Modelling; Taylor and Fourier series expansion; Root finding; Interpolation, splines, extrapolation; Regression and curve fitting; Solution of simultaneous linear algebraic systems; nonlinear algebraic equations; Eigenvalues and eigenvectors; Solution of simultaneous nonlinear algebraic systems; Numerical integration, Simpson’s rule,

Gaussian quadrature; Solution of ODE: R. K. Methods; Predictor-Corrector methods; boundary value problems; Systems of ODEs; convergence and error studies; Linear PDEs by finite differences.

Prerequisites: NA

ME613 Microfluidics (6 Credits)

Introduction: Significance in fundamental and applications; Governing equations: mass, momentum and energy and species conservation equations; Boundary conditions; Pressure driven flows; Surface tension driven flows and it's modulation; Unsteady flows; Electrokinetic flows; Stokes drag on sphere; Introduction to lubrication theory; Gas flow through micro conduits; Biomicrofluidics; Microfluidics components; Introduction to microfabrication.

Prerequisites: ME212 (Fluid Mechanics)

ME614 Electronic Cooling Systems (6 Credits)

Introduction; heat transfer modes, thermal spreading and contact resistance, microscale heat transfer; Fin analysis, heat sink design optimization, Air and liquid jet impingement, immersion cooling, phase change energy storage, multi-mode heat transfer; Thermal systems analysis, cold plates and heat exchangers, flow network modeling, compact models, acoustic and mechanical design issues; Microscale measurement techniques; Emerging technologies.

Prerequisites: NA

ME615 Computational Fluid Dynamics (6 Credits)

Conservation laws of fluid motion and boundary conditions: Governing equations, conservation vs non-conservation, Differential vs integral forms of general transport equations, classification of physical behaviours, classification method for simple PDEs; finite volume method for diffusion problems; finite volume method for convection-diffusion problems: differencing schemes; Solution of discretised equations: TDMA, Iterative methods; Solution algorithms for pressure-velocity coupling in steady flow: SIMPLE algorithm; The finite volume method for unsteady flows: Explicit scheme, Crank-Nicolson scheme, fully implicit scheme; Errors and uncertainty in CFD modelling. Application of CFD to analyze engineering problems.

Prerequisites: NA

ME616 Interfacial Transport Phenomena (6 Credits)

Introduction: Basic concepts of interfaces and transport.

Capillarity: Deformable interfaces, emphasis on the effect of surface tension, liquid at interfaces, Surface curvature, Contact Angles and measurement.

Surface wettability: Hydrophilic, hydrophobic and superhydrophobic surfaces, and variable wettability gradient surfaces.

Hydrodynamics of wetting: Thin films, droplets, bubbles, puddles and waves.

Dynamics of Liquid-droplet in detail: Focus will be on droplet Impact (Fluid dynamics aspect) and evaporation (Fluid dynamics and Heat Transfer aspect) in detail. Droplet spreading, receding, bouncing, nonbouncing, partial bouncing, splashing. The partial differential equations and their solutions for these problem. Scaling approximations.

Surfactants: Applications, Soap films and bubbles.

Basics of manipulation of fluids and its applications in microchannels.

Colloidal Deposits and its interfaciat science: Coffee ring effect, blood-stain patterns, colloidal particle-sorting, etc.

Special Topics: Applications in Forensic science, biotechnology, energy and sustainable environment.

Prerequisites: Fundamentals of Physics, Mathematics (Partial differential Equations)

ME617 Multiphase Flow and Heat Transfer (6 Credits)

Introduction of multiphase flow: Various definitions, examples and industrial applications; multiphase Flow regime types and their definitions; analysis of flow regimes and the simple analytical models; homogeneous flow model, Drift flux model, Separated flow model; two phase flows: Boiling heat transfer, boiling regimes, heat transfer in different regimes of boiling, Instabilities of vapor layer; quenching/Rewetting and its analytical model; two-Phase Natural circulation loop and Heat Transfer; condensation and its types: Homogeneous, Heterogeneous, Dropwise, Filmwise condensation.; measurement Techniques for the multiphase flow parameters: Void fraction measurement, estimation of flow patterns.

Prerequisites: UG students - Fluid Mechanics (ME212), Heat and Mass Transfer (ME213)

ME632 Fracture Mechanics (6 Credits)

Introduction; Background and history of fracture; Energy release rate; Crack-tip deformation and stress fields; Stress intensity factor; Westergaard's approach; Elasto-plastic fracture mechanics, CTOD; J-Integral; Test methods; Fatigue failure and environment assisted fracture; Numerical analysis of cracks; Mixed mode crack initiation and growth.

Prerequisites: ME231/ME531

ME633 Finite Element Method (6 Credits)

Introduction and historical background; Background on variational calculus: Galerkin methods, Collocation methods, Least-squares methods. Variational methods of approximation-Rayleigh-Ritz method, variational theorems; 1D FEM; Trusses; Beams and frames; 2D problems: Constant strain triangles, Axisymmetric problems; Isoparametric elements; 3D problems; Shell analysis; Solution of heat conduction, fluid flow, vibration, and stability.

Prerequisites: NA

ME634 Composite Materials (6 Credits)

Introduction to the fiber reinforced composite materials: Basic terminologies, Advantages of composite, Applications, Manufacturing of FRC materials; Macromechanical and Micromechanical behaviour of a lamina; Macromechanical behaviour of a laminate; Analysis of laminated plates and beams; Fracture mechanics of FRP composites; Fatigue; Environmental effects; Experimental characterization of composites.

Prerequisites: ME231/ME531

ME652 Automation (6 Credits)

Introduction to manufacturing, Manufacturing system concept. Manufacturing automation, FMS, CIMS, Flow lines and assembly systems, Automated storage /retrieval systems, AGV.

Introduction to CAD/CAM, NC, CNC, DNC, Adaptive control. Manual and computer assisted part programming. Introduction to robots and their application in manufacturing. Process planning and Computer Aided Process planning. Group Technology, Opitz System and GT benefits.

Prerequisites: NA

ME653 Experimental Methods in Fluids and Thermal Science (6 Credits)

Analysis of Experimental Data: Causes and types of experimental error, uncertainty analysis, statistical analysis of data, probability distributions and curve fitting; Dynamic performance characteristics; Input types; Instrument types- zero order instrument, first-order instrument, second-order instrument;

Measurement of pressure: design of Pitot and Pitot static tubes, factors affecting the measurements of Pitot/Pitot Static Tubes: Alignment, wall effects, turbulence etc., the effect of flow compressibility on pressure measurements of PST, methods of measuring static and Pltot/stagnatlon pressure In the compressible flow. Flow measurements: 3 hole and 5 hole probes, directional sensitivity of 3 hole and five-hole probes, Hotwire anemometry (HWA): detail analysis of constant current anemometer (CCA) and constant temperature anemometer (CTA), comparison of CCA and CTA, measurements of fluctuating velocity in turbulent flow, Laser Doppler Velocimetry/Anemometry (LDV/LDA), Particle Image Velocimetry (PIV), micro-PIV, Flow visualization methods; Temperature Measurements: Details of Thermocouple measurements and its calibration; Liquid crystal thermography (LCT), InfraRed Thermography (IRT), optical methods for temperature and density measurements: qualitative and quantitative analysis through Interferometer, Schlieren and Shadowgraph;

Prerequisites: Fluid Mechanics, Heat Transfer and Thermodynamics

ME654 Advanced Materials - Development and Characterization (6 Credits)

Advancement in engineering materials - Role of alloys, ceramics, intermetallics and other special class of materials in automobile and aerospace applications.

Development and characterization practice: Material identification - Development by conventional / unconventional material development route – microstructural characterization (Optical and Electron microscopies, XRD, etc) - mechanical performance (Room and high temperature properties, tribological characteristics, etc.). Documenting and reporting the results.

Prerequisites: ME553

ME673 Computational Fluid Dynamics Laboratory (1 Credits)

Modelling and analysis of various fluid flow and heat transfer problems involving:

Internal fluid flow: Flow through pipe and channels, sloshing and other similar problems.

External fluid flow: Flow over aerofoil/wing and automobiles; flow over stationary and rotating cylinder (magnus effect), and other similar problems.

Forced convection: Flow through pipe/channels; problems involving electronics cooling and jet impingement cooling.

Free convection: Natural convection cooling and heating; coupled natural convection-radiation problems.

Prerequisites: Fluid Mechanics and Heat & Mass Transfer

ME674 Finite Element Analysis Lab (1 Credit)

1. Preprocessing: Material model, boundary condition, mesh type, contact condition etc
2. Mesh sensitivity analysis
3. Simulation of various engineering problems from the domain of mechanical engineering such as structural analysis of components, deflection of beam, thermal analysis, metal cutting, welding etc.

Prerequisites: NA

ME795 Candidacy (0 Credit)

The objective of this candidacy is to evaluate the candidate's ability to carry out research and shall include the evaluation of the knowledge breadth of the student, including the research comprehension.

Prerequisites: Student must have completed the course credit requirement for the program registered for.

ME798 Independent Study (variable Credits)

Students registering for this course are expected to get versed in a particular topic allotted by the course instructor. The topic and the credits are assigned by the course instructor. There will not be any regular lecture delivered for this course type.

Prerequisites: The course is available only to PG students.

ME799 Thesis (variable Credits)

Students registering for this course are associated with a supervisor and have to carry out research work. Student will be evaluated for the program in research at the end of semester.

Prerequisites: Student must have cleared candidacy.

Courses in Physics

PH200 Laser Physics (2 Credits)

The course will cover topics starting from the introduction to lasers and basic laser physics to resonators and lasers in everyday use. The topics would include optical radiation processes, conditions for the amplification of radiation, three level and four level lasers, resonators and cavity designs, practical laser systems till date, with their applications.

Prerequisites: NA

PH201 Nonlinear Optics (2 Credits)

The course would be meant to introduce the students to the field of nonlinear optics. The course thus would include the origin of nonlinearity, nonlinear optical interactions, intensity dependent refractive index, linear and nonlinear absorptions, nonlinear optical materials, sources based on nonlinear optical interactions and their applications.

Prerequisites: NA

PH202 Photonics (2 Credits)

The course will provide introduction and basics of laser physics, nonlinear optics and fiber optics. The topics covered will be optical radiation processes, conditions for the amplification of radiation, laser system, origin of nonlinearity, nonlinear optical interactions, linear and nonlinear absorptions, dielectric waveguide, dispersion, fiber parameters.

Prerequisites: NA

PH203 Thin Film Science and Technology (2 Credits)

Thin film research shares the knowledge from multi-disciplines (e.g., materials science, chemistry, solid state physics, mechanics and etc.). This course is designed for those students who are interested in thin film fundamentals and processing for various industrial applications. Topics include, but are not limited to, fundamentals on crystal structures and defects in thin films, the basic nucleation and growth mechanisms of thin films (growth models, lattice matching epitaxy and domain matching epitaxy), thin film processing techniques (CVD, MOCVD, MBE, PLD, Laser-MBE, sputtering, and evaporation etc.), thin film growth instrumentation aspect (energy source, chamber configurations, vacuum systems and growth controllers), and several advanced topics related to electrical and optical devices. Lab-tour session(s) will be arranged to promote learning.

Prerequisites: NA

PH204 Photovoltaics (2 Credits)

There is no doubt about the fact that for the widespread substitution of fossil fuel and to meet future energy needs, solar cells have to play a key role in that. This course will introduce the fundamentals of photoelectric conversion: charge excitation, conduction, separation, and collection. The course will introduce the working principles, characterization techniques, limitations or technological hurdles, grid-parity and material aspects of different types of solar

cell technologies. Latest results and breakthroughs in materials and technology will also be discussed.

Prerequisites: NA

PH205 Relativity (2 Credits)

Galilean transformations, postulates of special theory of relativity, Lorentz transformations, length contraction, time dilation, relativistic mass, relativistic energy and momentum, notion of space, time and space-time, space-time diagram, Lorentz group, equivalence principle and general theory of relativity.

Prerequisites: NA

PH206 Light Absorption, Emission and evice (2 Credits)

Optical absorption and reflection (fundamentals, X- rays to microwaves), cyclotron resonances, excitons, polarons, plasmons, radiative and non-radiative carrier recombination, excitonic signatures in photoluminescence. Optical properties of OD, 10 and 20 semiconducting materials, quantum-dot-based light emitting diodes (lnGaN, GaP etc) and transistor (lnGaP, GaAs etc), semiconductor LASERS (GaAs, AIGaAs, etc), quantum-dot-based LASERS (eg lnGaAs) and optical properties of superlattices. Miscellaneous semiconductors (amorphous, organic, fullerenes, carbon nanotubes), molecular electronics, photoconductivity and dynamics, photovoltaics. Rayleigh, Raman and Brillouin scattering phenomena.

Prerequisites: NA

PH207 Quantum Optics and Information Processing (2 Credits)

Classical optics, quantum properties of light, photon statistics, single photon source, polarizing beam splitter (analogy with Stern-Gerlach experiment), polarization state of a single photon, single photon polarization detector, Pockets cell, light amplifier, basic principles of quantum cryptography, quantum cryptographic systems and limitations, quantum key distribution-8884, -892 protocols, qubits, quantum logic gates, decoherence, error correction and applications of quantum computers.

Prerequisites: NA

PH208 Self-Propelled Micro/Nanorobots (2 Credits)

Mechanism of propulsion at small scale (low Reynolds numbers), Scaling laws, Design strategies for self-propelled micro/nanorobots under different environmental conditions (e.g. aqueous and complex viscoelastic or biological media), Techniques of the localization and manipulation (external and self-guided motion). Observation and tracking methods.

Micro/nanorobots for the applications in targeted drug delivery, non-invasive surgery, environmental sensing, cargo delivery, and formation of dynamic and reconfigurable self assemblies.

Prerequisites: NA

PH209 Unfurling Neutrino Stories (2 Credits)

1. History of Neutrinos: From Pauli to Fermi's theory to six Nobel Prizes in neutrino physics

2. Fundamental Constituents of our Universe (quarks, leptons, photon, W,Z bosons, Higgs) and forces: [electromagnetic, weak, Strong and gravitational interactions.
3. Status of Neutrinos in Weinberg, Salam and Glashow's SM of Particle Zoo.
4. Brief Idea about Solar, atmospheric, reactor/accelerator, supernovae neutrinos.
5. Neutrino oscillations and efforts by Indian Neutrino Observatory.
6. Neutrino Astronomy, Icecube Telescope: Neutrinos from Heaven.
7. Current Research Perspectives of Neutrino Physics in purview of Particle Physics, Astrophysics and Cosmology.

Prerequisites: NA

PH501 Classical Mechanics (6 Credits)

Review of Newtonian mechanics, Lagrangian mechanics, generalized coordinates, constraints, principle of virtual work, Lagrange's equation, calculus of variations, central forces, collisions, scattering small oscillations, anharmonic oscillators. perturbation theory, forced oscillators. Hamilton's equations, phase space & phase trajectories, canonical transformations, Poisson brackets, Hamilton- Jacobi theory, rigid body dynamics, nonlinear dynamics; Special Theory of Relativity: Relativistic Kinematics, Mass Energy equivalence, Continuous System.

Prerequisites: NA

PH502 Quantum Mechanics-I (6 Credits)

Origins of quantum theory, Schrödinger equation, wave mechanics, one and three-dimensional problems, Harmonic and other potentials; hydrogen atom, Hilbert space formalism for quantum mechanics, symmetries in quantum mechanics, general treatment of angular momentum; spin, identical particles; Pauli exclusion principle.

Prerequisites: NA

PH503 Mathematical Physics (6 Credits)

Vector space, orthogonality, matrices, Cayley-Hamilton Theorem, eigenvalues, eigenvectors; Complex variable, Singularities, Taylor and Laurent series, residue theorem, contour integration; Fourier series, Fourier transformation, Laplace transformation; Special function: Gamma, Hermite, Bessel, Legendre, Laguerre and Green functions; Introduction of tensor and group theory, representation of O(N), SU(N).

Prerequisites: NA

PH504 Computational Physics (6 Credits)

C Programming Language: Algorithms, flow charts, constants, expressions, conditional statements, loops, arrays, logical expressions, control statements, functions, structures, pointers, bit operation, files in C. Solving problems using C programming. Numerical Analysis: Interpolation by Lagrange method, Numerical solution of simple algebraic equation by Newton- Raphson method, Least Square fit using rational functions, Numerical integration: Trapezoidal method, Simpson's method, Romberg integration, Gauss quadrature method, Eigenvalues and eigenvectors of a matrix, Solution of linear homogeneous equations, Trace of a matrix, Matrix inversion, Solution of ordinary differential equation by Runge-Kutta Method, Introductory Monte Carlo techniques.

Prerequisites: NA

PH505 Electronics Laboratory (6 Credits)

Bipolar junction transistor (BJT) - characteristics, MOSFET characteristics, Cathode Ray Oscilloscope (CRO), Logic Circuit, Light Emitting Diode (LED) characteristics, Thin Film Deposition and its characterization, Characteristics of Solar cell, Photoluminescence, Raman effect experiment.

Prerequisites: NA

PH506 Statistical Physics (6 Credits)

Classical Statistical Mechanics: Postulate of classical statistical mechanics, Liouville's theorem, micro canonical ensemble, Derivation of thermodynamics, equipartition theorem, classical ideal gas, Gibb's Paradox. Canonical ensemble and energy fluctuation, grand canonical ensemble and density fluctuation, Equivalence of canonical and grand canonical ensemble; Quantum Statistical Mechanics: The density matrix, ensembles in quantum statistical mechanics; Ideal gas in micro-canonical and grand canonical ensembles; Equation of state for ideal Fermi gas, Theory of white dwarf stars. Ideal Bose Gas, Photons and Planck's law, Phonons, Bose-Einstein condensation; Phase Transition: Thermodynamic description of phase transitions, phase transitions of second kind, Discontinuity of specific heat, change in symmetry in a phase transition of second kind. Ising model : Definition of Ising model, One Dimensional Ising model; Ideal Bose Gas, Photons and Planck's law Phonons, Bose- Einstein condensation; Thermodynamics description of phase transitions, phase transitions of second kind, Discontinuity of specific heat, change in symmetry in a phase transition of second kind.

Prerequisites: NA

PH507 Quantum Mechanics – II (6 Credits)

Time Independent Perturbation Theory, First and Second Order Correction, Perturbed Harmonic Oscillator, Anharmonic Oscillator, The Stark Effect. Degenerate Perturbation Theory, Removal of Degeneracy.

Variational Methods: Ground State, First Excited State and Second Excited State of One-Dimensional Harmonic Oscillator, Ground State of H-atom and He-atom, Rotational and Vibrational Degrees of Freedom, Hydrogen molecule ion, Hydrogen molecule.

WKB Approximation Method: General Formalism, Validity of WKB Approximation Method, Connection Formulas, Bohr Sommerfeld Quantization Rule, Application to Harmonic Oscillator, Tunneling Through a Potential Barrier, Cold Emission, Alpha Decay

Time Dependant Perturbation Theory: Transition Probability, Constant and Harmonic Perturbation, Fermi's Golden Rule, and Electric Dipole Radiation and Selection rules.

Scattering Theory: Scattering Amplitude and Cross Section. Born Approximation. Application to Coulomb and Screened Coulomb Potential,. Partial Wave Analysis for Elastic and Inelastic Scattering, Optical Theorem, Hard-Sphere Scattering, Resonance Scattering from a Square Well Potential.

Prerequisites: NA

PH508 Electrodynamics (6 Credits)

Brief electromagnetism, Maxwell's equations, Poynting's theorem, Energy and momentum conservation; Electromagnetic waves: wave equation, propagation of electromagnetic waves in different media, reflection, refraction, and total internal reflection, complex refractive index; Multipole Radiation: Potential, Fields and radiation due to an oscillating electric dipole, angular distribution of power radiated, Rayleigh Scattering. Magnetic dipole and Electric Quadrupole radiation; Radiation by Point Charge: Lienard-Weichert potential, Field due to a point charge, Angular distribution of radiation and total power radiated by an accelerated charge, Thomson's scattering.

Prerequisites: NA

PH509 Nuclear and Particle Physics (6 Credits)

Ground state of Deuteron, Mesons and nuclear force field (Field theory of Nuclear forces); Liquid drop model and Weissacker's mass formula, Shell model of the nucleus, Fermi gas model Single particle shell model, Collective model of nucleus, rotational motion of the nucleus, vibration of spherical Nuclei; Description of nuclear Reactions, Q-value, derivation of elastic and reaction cross section, description by partial wave analysis, Resonances, Breit-winger one level formula; Accelerators and Detectors.

The Standard model of particle physics, particle classification, Spin and parity determination, Isospin, strangeness, hypercharge, and baryon number, lepton number, Gell-Mann-Nishijima Scheme, Quarks in hadrons: Meson and baryon octet, Elementary ideas of SU(3) symmetry, charmonium, charmed mesons and B mesons, Quark spin and colour.

Prerequisites: NA

PH510 Experimental Laboratory (6 Credits)

Typical set of experiments: Michelson Interferometer, X-Ray Diffraction, Planck's constant, Geiger-Muller counter, Hall effect, Faraday effect, Microwave Experiment, Electron Spin Resonance, 2D Grating, Kerr effect, Rydberg constant, Franck-Hertz experiment, Zeeman effect.

Prerequisites: NA

PH511 Atomic and Molecular Physics (6 Credits)

Review of one and two-electron atoms; Many electron atoms: central field approximation, Thomas-Fermi model, Hartee-Fock and self-consistent field methods, Hund's rule, L-S and j-j coupling, Equivalent and nonequivalent electrons, Spectroscopic terms, Lande interval rule; Interaction with Electromagnetic fields: Zeeman, Paschen Back and Stark effects; Hyperfine structure and isotope shift, selection rules; Lamb shift; Molecular spectra: rotational, vibrational, electronic, Raman and Infra-red spectra of diatomic molecules; Hund's rule, Frank–Condon principle; Molecular structure: molecular potential, Born-Oppenheimer approximation, diatomic molecules, electronic angular momenta; Modern developments: optical cooling and trapping of atoms, Bose- Einstein condensation, Introduction of LASER physics.

Prerequisites: NA

PH512 Solid State Physics (6 Credits)

Crystal structure: Miller indices and reciprocal lattice, Bragg and von Laue diffraction, structure factor; Lattice vibration and thermal properties: harmonic approximation, monatomic and diatomic lattices, Brillouin zone, density of states, acoustic and optical modes, phonons, crystal momentum, Debye model of specific heat, thermal expansion, thermal conductivity; Free electron theory: Fermi gas, specific heat, Ohm's law, magneto-resistance, thermal conductivity; Band theory: Bloch theorem, nearly free electron model, motion of electron in energy bands, effective mass; Semiconductor: Intrinsic and extrinsic semiconductors, mobility and electrical conductivity, Fermi level, Hall effect; Magnetism: Diamagnetism, Hund's rules, Lande g-factor, quantum theory of paramagnetism, Pauli paramagnetism, exchange interaction, ferromagnetism, hysteresis; Superconductivity: Meissner effect, London equations, type-I and type-II superconductors; Ginzburg-Landau theory, outlines of BCS theory.

Prerequisites: NA

PH513 Experimental and Measurement Techniques (6 Credits)

The range of experimental methods covers X-ray diffraction technique-Neutron diffraction; Fundamentals of electron microscopy (SEM, TEM, Electron diffraction, STEM); Electron Probe Microanalysis (EPMA) (EDS, WDS); Scanning tunneling microscopy (STM) and atomic force microscopy (AFM); Electron emission spectroscopies (XPS, AES, UPS); Vibrational spectroscopy (IR, Raman); Resonance techniques (NMR, ESR); Lithography- optical, e-beam etc; chromatographic techniques (size exclusion chromatography, liquid chromatography, gas chromatography); mass spectroscopy (ESI-MS, MALDI-TOF); surface area analysis of porous materials, oxygen/moisture permeability analysis; mechanical testing; rheology. Whenever possible lab tours will be arranged showing the equipment in practical use.

Prerequisites: NA

PH514 Electronics (6 Credits)

Network theorems; application to simple circuits; p-n junction devices, diode, transistors; biasing schemes; small signal amplifiers; feed-back; theory; oscillators; power supply; wave shaping circuits; Bipolar junction transistor: configurations, small signal amplifier, oscillators; JFET and MOSFET: characteristics, small signal amplifier; OP-AMP: Differential amplifiers; Op-Amp (741) circuits (amplifiers; scalar; adder;subtractors; comparator; logarithmic amplifiers; etc.); Number systems and their inter-conversion; Boolean algebra; Logic gates; De-Morgan's theorem; Logic Families: TIL, MOS and CMOS; Combinational Circuits: Adders, subtractors, Encoder, etc.; Sequential Circuits: Flip-flops, Registers, Counters, Memories;
A/D and D/A conversion Microprocessor and microcontroller basics

Prerequisites: NA

PH515 Semiconductors and Applications (6 Credits)

Introduction to thin films and nanostructures; Growth modes and zone models; techniques for fabrication of semiconductor thin films and nanostructures using sputtering, e-beam evaporation, atomic layer deposition, electrospinning, dry and wet etching, chemical vapour deposition, sol-gel, spin-coating, and Langmuir-Blodgett technique etc. Characterization of optical, electrical, mechanical and structural properties using various techniques. Interaction of ultraviolet and visible photons with semiconductors; charge excitation, formation of excitons and polarons in general and molecular semiconductors; dynamics of photogenerated carriers;

some specific examples for the dynamics of charge carriers; photovoltaic effect: conduction, separation, and collection; working principles, photovoltaic characterization techniques, limitations or technological hurdles, and material aspects of different generation of solar cell technology.

Prerequisites: NA

PH517 Astrophysics & Cosmology (6 Credits)

Astrophysics: basics, spectra, radiative transfer, stars, end-states of stars (white dwarfs, Chandrasekhar's mass limit, neutron stars, supernovae, black holes), quasars, gamma ray bursts, interstellar medium, galaxies, astrophysical fluids & plasmas, instabilities, magnetohydrodynamics, applications to stars/galaxies and the Universe.

Einstein's relativity: special relativity, equivalence principle, basics of general relativity. Cosmology: redshift, FRL W models of the Universe, expansion, Hubble's law, the early Universe, big-bang model, inflation, nucleosynthesis, matter and radiation dominated era, dark matter, dark energy, cosmic microwave background, baryon acoustic oscillations, formation of galaxies and stars, current forefront of research, supermassive black holes, first stars, epoch of reionization, 21 cm cosmology, N-body simulations

Prerequisites: NA

PH602 Solid State Physics (6 Credits)

Crystal structure: symmetry operations, Bravais lattices, point groups, examples of simple crystal structures, Miller indices and reciprocal lattice, Bragg and von Laue diffraction, structure factor;

Lattice vibration and thermal properties: harmonic approximation, monatomic and diatomic lattices, Brillouin zone, density of states, acoustic and optical modes, phonons, crystal momentum, determination of dispersion relations, Debye model of specific heat, anharmonic effects, thermal expansion, thermal conductivity;

Free electron theory: Fermi gas, specific heat, Ohm’s law, magneto-resistance, thermal conductivity; Band theory: Bloch theorem, nearly free electron model, classification of metal, insulator and semiconductor, motion of electron in energy bands, effective mass, Fermi surfaces of metals; Semiconductor: Intrinsic and extrinsic semiconductors, mobility and electrical conductivity, Fermi level, Hall effect;

Magnetism: Diamagnetism, Hund’s rules, Lande g-factor, quantum theory of paramagnetism, Pauli paramagnetism, exchange interaction, ferromagnetism, Ising model, Heisenberg model, hysteresis; Superconductivity: Meissner effect, London equations, type-I and type-II superconductors; Ginzburg-Landau theory, outlines of BCS theory.

Prerequisites: NA

PH604 Advanced Quantum Mechanics (4Credits)

Klein-Gordon equation and its drawbacks, Dirac equation, Properties of Dirac Matrices, Non-

relativistic reduction of Dirac equation.

Covariant form of Dirac equation, magnetic moment, Darwin’s term, Spin- orbit coupling, bilinear

covariant, Lorentz Covariance of Dirac equation, Free particle solution of Dirac equation, Projection operators for energy and spin.

Physical interpretation of free particle solution, Zitterbewegung, Hole theory, Charge conjugation, Space reflection and Time reversal symmetries of Dirac equation.

Continuous systems and fields, Transition of discrete to continous systems, Lagrangian and Hamiltonian formulations, Noether's theorem

Second quantization, Quantization of neutral scalar field, and charge scalar field, (Expansion of fields in terms of creation, annihilation operator and number operator, unequal space time commutators, anti commutators, propagator functions and their integral representations, Vacuum expectation value, Time ordered product, Feynman propagator).

Dirac field and electromagnetic field (Expansion of fields in terms of creation, annihilation operator and number operator, unequal space time commutators, anti commutators, propagator functions and their intergral representations, Vacuum expectation value, Time ordered product, Feynman propagator)

Prerequisites: NA

PH605 Quantum Field Theory (6 Credits)

Relativistic quantum mechanics – Klein-Gordon equation, Dirac equation, free-particle solutions

Lagrangian formulation of Klein-Gordon, Dirac and Maxwell equations, Symmetries (Noethers theorem), Gauge field, Actions. Canonical quantization of scalar and Dirac fields. Interacting fields – Heisenberg picture, perturbation theory, Wicks theorem, Feynman diagram

Cross-section and S-matrix. Quantization of gauge field, gauge fixing. QED and QED processes. Radiative corrections – self-energy, vacuum polarization, vertex correction. LSZ and optical theorem. Introduction to renormalization.

Prerequisites: NA

PH606 Particle Physics (6 Credits)

The Standard model of particle physics, particle classification, fermions and bosons, lepton flavors, quark flavors, electromagnetic, weak and strong processes, Spin and parity determination, Isospin, strangeness, hypercharge, and baryon number, lepton number, Gell-Mann-Nishijima Scheme, Quarks in hadrons: Meson and baryon octet, Elementary ideas of SU(3) symmetry, charmonium, charmed mesons and B mesons, Quark spin and colour.

Dirac equation, Scattering processes of spin-1/2 particles (Feynmans rules as thumb rule), propagators

Current-current interactions, weak interaction, Fermi theory Gauge symmetries, spontaneous symmetry breaking, Higgs mechanism

Electroweak interaction, Glashow-Salam-Weinberg model Introduction to QCD, structure of hadrons (form factors, structure functions), parton model, Deep inelastic scattering.

Prerequisites: NA

PH607 Relativistic Matter at finite magnetic field (6 Credits)

Two-body to N-body coupled oscillators to Continuous System, Relativistic ideal and dissipative Hydrodynamics, Magneto Hydrodynamics, Kinetic Theory in presence of magnetic field, quantum aspect of magnetic field, Landau quantization, quantum Hall effect, quantum field theory at finite temperature and magnetic field, Propagators at finite temperature, Propagators at finite magnetic field, Application towards High Energy Nuclear Physics and Astra Physics.

Prerequisites: Classical Mechanics (PH501), Quantum Mechanics-1 (PH502), Quantum Field Theory (PH605)

PH657 Feynman Diagram Calculation (2 Credits)

Motivation, Anatomy of S-matrix, structure of propagator and self-energy in vacuum as well as medium for spin 0, ½ and 1 particles, Application of Feynman diagram in particle and nuclear physics.

Prerequisites: NA

PH699 Thesis (variable Credits)

Students registering for this course are associated with a supervisor and have to carry out research work. Student will be evaluated for the program in research at the end of semester.

Prerequisites: NA

PH795 Candidacy (0 Credit)

The objective of this candidacy is to evaluate the candidate's ability to carry out research and shall include the evaluation of the knowledge breadth of the student, including the research comprehension.

Prerequisites: Student must have completed the course credit requirement for the program registered for.

PH798 Independent Study (variable Credits)

Students registering for this course are expected to get versed in a particular topic allotted by the course instructor. The topic and the credits are assigned by the course instructor. There will not be any regular lecture delivered for this course type.

Prerequisites: The course is available only to PG students.

PH799 Thesis (variable Credits)

Students registering for this course are associated with a supervisor and have to carry out research work. Student will be evaluated for the program in research at the end of semester.

Prerequisites: Student must have cleared candidacy.