Courses of Study

BTech & BDes

Contents

Created on August 6, 2019

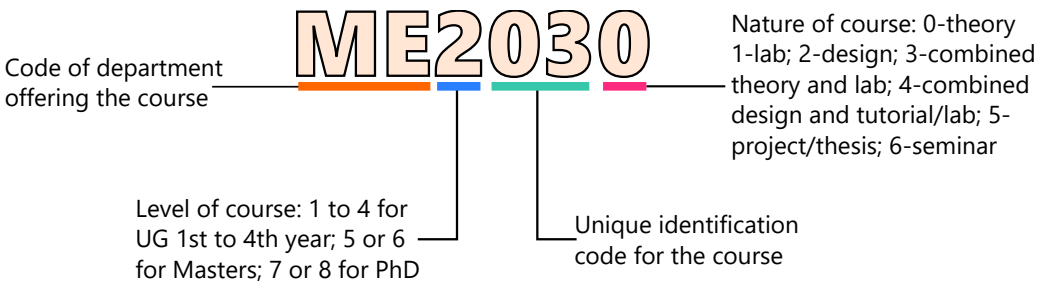
1 | Introduction

1.1 Glossary of Terms

- **Credit:** The quantitative measure of recognition given to a course, stated in semester hours. Typically, a theory course running for a full a semester with three contact hours per week would be 3 credits. Similarly, a lab course with the same number of contact hours would be 2 credits.
- **Major:** The primary set of discipline-specific coursework pertaining to the student's department/discipline
- **Minor:** Additional basket of coursework done from a discipline different from the student's original discipline (and would also find mention in the final degree) Honors: Additional basket of coursework done in the same discipline as the student's original discipline (and would also find mention in the final degree)
- **Double Major:** Coursework pertaining to two departments/disciplines and leading to two separate degrees.
- **Additional Course:** An additional course taken by the student over and above the minimum credit requirements of the degree. Pre-requisite: The preliminary requirement, usually successful completion of another course, that must be met before a course can be taken.
- **Elective:** Course chosen by the student and which would form part of his/her degree requirements.
- **Free Elective:** A course of the student's choice, to be selected from the any department (subject to meeting the pre-requisites)
- **Core Elective:** A course of the student's choice, to be selected from the same department (or offered by a different department, but identified as "core" by one's department)
- **LA/CA Elective:** A course of the student's choice, to be selected from the Liberal Arts and Creative Arts category
- **Science Elective:** A course of the student's choice, to be selected from the Maths, Physics & Chemistry list of courses
- **Fractal Segment:** The part or duration of a semester in which a particular course is offered

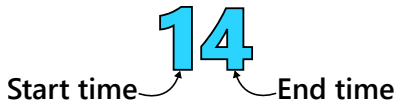
1.2 Course Numbering Scheme

Each course is denoted by a course number consisting of two letters followed by four numerals.



1.3 Fractal Segments

In the fractal system, a semester is divided into six segments. Each segment is approximately 2.5 to 3 weeks in duration. Every fractal course is accompanied by a two-digit segment number indicating the duration of the course. The first number denotes the segment in which a course will begin and the second number the segment in which it will be completed. For example, Segment 34 means, a particular course will begin in segment-3 and finish at the end of segment-4. Typically, a course running for full the semester (i.e., all six segments) would be 3-credits; so each segment will be equivalent to 0.5 credit. Accordingly, the credit of a course will be decided, based on its segment data. For example, if the segment of a course is 56, it implies that the course will be running in two segments (5 & 6). Hence, it will be $0.5 \times 2 = 1$ credit.



	SEMESTER					
SEG CREDITS	1	2	3	4	5	6
0.5	11	22	33	44	55	66
1.0	12		34		56	
1.5	13			46		
2.0	14					
2.0			36			
3.0	16					

2 | Department of Artificial Intelligence

2.1 BTech

- Since this is a new program, the curriculum is subject to modifications. Please see the Department of AI website for the up to date curriculum
- At least 2 credits must be taken each from the Emerging technologies; AI, Health and Humans; and Smart Industry baskets

Code	Cred.	Course Title	Segments
Semester 1			
MA1110	1	Calculus - I	12
MA1220	1	Calculus- II (Multivariable Calculus)	34
MA1230	1	Series of Functions	56
AI1001	1	Introduction to Modern AI	56
AI1002	1	Introduction to Drones	56
CS1310	2	Discrete Structures I	
ID1054	2	Digital Fabrication	16
ID1035	1	Independent Project	16
ID1303	2	Programming in C/C++ With Lab	
AI1003	2	Probability and Random Variables	14
PH/CY	1	Science Elective	
LAXXXX	1	LA / CA Electives	
Semester 2			
MA1130	1	Vector Calculus	12
AI1101	3	Linear Algebra	16
MA1150	1	Differential Equations	56
CS1340	2	Discrete Structures II	
CS1353	3	Introduction to Data Structures	
ID1370	0	None	
MA2140	1	Introduction to Statistics	34
EE1210	1	Basic Control Theory	
LAXXXX	1	LA / CA Electives	
PH/CY	1	Science Elective	
AI1150	1	Independent Project	
Semester 3			
MA2120	1	Transform Techniques	
AI2001	3	Basics of Machine Learning	16
AI2002	2	Artificial Intelligence	14
MA2143	2	Statistical Inference	36
CS2400	1	Principles of Programming Languages I	
CS3510	1	Operating Systems I	
CS3550	1	Introduction to Database Management Systems	
CS2323	2	Computer Architecture	
AI2003	1	Stochastic Processes	56
EE1110	1	Applied Digital Logic Design	
AI2004	1	IoT	12

Code	Cred.	Course Title	Segments
LA1500	1	What is AI And Humanity?	56
AI2050	1	Independent Project	
Semester 4			
CS2443	3	Algorithms	
CS2420	1	Introduction to Complexity Theory	
CS3523	3	Operating Systems II	
EE2340	1	Information Science	
CS3563	3	Database Management Systems (with Lab)	
AI2101	3	Deep Learning	16
AI2102	2	Reinforcement Learning	14
AI2150	1	Independent Project	
Semester 5			
AI3001	2	Robotics	14
AI3002	1	Introduction to Brain and Neuroscience	12
AIXXXX	6	AI Electives (baskets Below)	
AI3003	1	Principles of Industry 4.0	34
CS3530	1	Computer Networks I	
FE	2	Free Electives	
LAXXXX	1	LA / CA Electives	
PH/CY	1	Science Elective	
AI3050	1	Independent Project	
Semester 6			
AI3101	1	Data Visualization	12
AI3102	1	Sequence Models	34
AI3103	2	Bayesian Data Analysis	36
AIXXXX	4	AI Electives (baskets Below)	
CS3543	3	Computer Networks II	
FE	2	Free Electives	
LA/CA	1	LA / CA Electives	
AI3150	1	Independent Project	
Semester 7			
AIXXXX	8	AI Electives (baskets Below)	
PH/CY	1	Science Elective	
FE	3	Free Electives	
LAXXXX	3	LA / CA Electives	
Semester 8			
AIXXXX	8	AI Electives (baskets Below)	
PH/CY	1	Science Elective	
ID4006	2	Ethics and Values	36
LAXXXX	2	LA / CA Electives	
FE	3	Free Electives	
Electives: Core AI and ML			
EE5603[1]	1	Concentration Inequalities	
EE5604	1	Introduction to Statistical Learning Theory	
EE5605	1	Kernel Methods	
CS6230	3	Optimization Methods in Machine Learning	
EE5606	2	Convex Optimisation	
EE5327	1	Optimization	56
MA5120	3	Numerical Linear Algebra	
CS6510	3	Applied Machine Learning	
EE5601	1	Representation Learning	
EE5602	1	Probabilistic Graphical Models	
EE5390	1	Source Coding	34

Code	Cred.	Course Title	Segments
EE6317	1	Channel Coding	56
Electives: Applied AI and ML			
CS5290	3	Computer Vision	
CS5330	2	Introduction to Statistical Natural Language Processing	
EE6307	3	Speech Systems	
EE6310	3	Image and Video Processing	
CS6370	3	Information Retrieval	
Electives: Data Analytics			
CS5170[2]	0	Predictive Analysis	
CS6670	3	Topics in Data Mining	
XXXXX	0	Time Series Analysis	
XXXXX	0	Graph Analysis for Big Data	
XXXXX	0	Distributed Systems	
XXXXX	0	Cloud Computing	
AI5110	2	Big Data - Tools and Techniques	36
Electives: Emerging Technologies			
XXXXX	0	Principles of Cyber Security	
XXXXX	0	Computer Forensics	
XXXXX	0	Bitcoins and Cryptocurrencies	
CS5130	3	Cryptography	
XXXXX	0	Randomized Algorithms	
CS5100	0	Quantum Computing	
Electives: AI, Health and Humans			
XXXXX	0	Bioinformatics	
XXXXX	0	Gene Editing	
XXXXX	0	Applications of AI in Healthcare	
XXXXX	0	Theoretical and Computational Neuroscience	
XXXXX	0	Neuromechanics	
XXXXX	0	Natural Intelligence	
Electives: Smart Industry			
XXXXX	0	Computer Integrated Manufacturing	
AI5010	2	Machine Diagnostics	14
ME3040	1.5	Mathematical Elements for Geometrical Modeling	13

1. At least 6 credits must be taken from the Core AI and ML basket. Any equivalent or related course can also be taken as an elective
2. At least 3 credits must be taken from the Data Analytics basket

3 | Department of Civil Engineering

3.1 BTech

Code	Cred.	Course Title	Segments
Semester 1			
ID1035	1	Independent Project	16
CY1017	1	Environmental Chemistry-i	12
ID1041	2	Engineering Drawing	16
ID1054	2	Digital Fabrication	16
ID1100	2	Fluid Mechanics - I	46
ID1130	2	Engineering Statics	13
ID1171	2	Fabrication Lab - I	16
ID1303	2	Programming in C/C++ With Lab	
MA1110	1	Calculus - I	12
MA1220	1	Calculus- II (Multivariable Calculus)	34
MA1230	1	Series of Functions	56
Semester 2			
CE2020	1.5	Construction Materials	
CE3512	1	Introduction To Environmental Engineering	12
CY1020	1	Dynamics of Chemical Systems-i	12
EE1330	1	DSP	34
ID1140	1	Thermodynamics - I	12
ID1150	2	Thermodynamics - II	36
ID1160	2	Solid Mechanics - I	13
LAXXXX	2	LA/CA Elective	
MA1130	1	Vector Calculus	12
MA1140	1	Elementary Linear Algebra	34
MA1150	1	Differential Equations	56
ME1030	2	Dynamics	46
Semester 3			
CE2021	2	Construction Materials Lab	16
CE2030	1.5	Concrete Technology	13
CE2031	1	Fluid Mechanics Lab	13
CY1031	2	Laboratory Experiments	16
EE1010	1	Electric Circuits	
ID1110	1.5	Fluid Mechanics - II	13
ID2020	2	Solid Mechanics - II	46
MA2110	1	Introduction to Probability	12
MA2120	1	Transform Techniques	
PH1017	1	Classical Physics	34
PH1031	2	Physics Lab	16
Semester 4			
BO1010	1	Introduction to Life Sciences	46
CE2100	1.5	Introduction To Structural Analysis	13
CE2101	2	Structural Mechanics Lab	46

Code	Cred.	Course Title	Segments
CE2110	1.5	Analysis Of Indeterminate Structures	46
CE3300	1.5	Geotechnical Engineering - I	13
CE3301	2	Geotechnical Engineering Lab	16
CE3310	1.5	Geotechnical Engineering - II	46
LAXXXX	2	LA/CA Elective	
MA2130	1	Complex Variables	12
MA2140	1	Introduction to Statistics	34
Semester 5			
BM1030	1	Bioengineering	
CE2500	2	Engineering Hydrology	14
CE3102	1.5	Introduction To Reinforced Concrete	13
CE3122	1.5	Reinforced Concrete Design	46
CE3312	1	Introduction To Foundation Engineering	12
CE3322	2	Design Of Foundations	36
CE3500	1.5	Introduction To Hydraulic Engineering	13
CE3501	1	Hydraulic Engineering Lab	56
CE3522	2	Water And Waste Water Engineering	14
CE3820	2	Highway Design And Materials	14
CE3830	1	Railway And Airport Engineering	56
XXXXXX	0-3	Core Electives / Projects	
Semester 6			
CE3010	2	Fundamentals Of GIS And Remote Sensing	14
CE3011	1	GIS Lab	34
CE3132	1.5	Design Of Steel Structures	46
CE3142	1.5	Introduction To Structural Steel Design	13
CE3510	1.5	Open Channel Hydraulics	13
CE3530	2	Air Pollution	14
CE3821	1	Highway Materials Lab	56
CE3840	2	Traffic Engineering And Planning	14
CE3841	1.5	Traffic Engineering Lab	46
LAXXXX	2	LA/CA Elective	
XXXXXX	0-3	Core Electives / Projects	
Semester 7			
CE3020	2	Surveying	
CE3511	2	Environmental Engineering Lab	16
CE4500	2	Water Resources Engineering	16
CE4900	2	Construction Management	16
LAXXXX	2	LA/CA Elective	
XXXXXX	3-6	Core Electives / Projects	
Semester 8			
CEXXXX	2	Environmental Impact Assessment	36
ID4006	2	Ethics and Values	36
LAXXXX	2	LA/CA Elective	
XXXXXX	3-6	Core Electives / Projects	
XXXXXX	6	Free Electives	
Departmental Course			
CE6540	3	Contaminant Hydrology And Remediation	
CE6580	3	Solid and Hazardous Waste Management	
CE6510	3	Water And Wastewater Engineering	
CE6520	3	Air Pollution	
CE6300	3	Advanced Foundation Engineering	
CE6310	3	Advanced Soil Mechanics	
CE6340	0	Ground Modification Techniques	
CE6330	3	Soil Dynamics	

Code	Cred.	Course Title	Segments
CE6352	3	Design Of Earth Structures	
CE6130	3	Finite Element Analysis	
CE6222	3	Prestressed Concrete Design	
CE6120	3	Applied Elasticity And Plasticity	
CE4102	0	None	
CE6140	3	Structural Dynamics	
CE6110	3	Advanced Structural Mechanics	
CE6232	3	Advanced Steel Design	
CE6500	3	Engineering Hydrology And Hydrologic Systems	
CE6610	3	Remote Sensing and GIS Applications To Civil Engineering	
CE6530	3	Groundwater Modeling	
CE6011	2	Computer Methods In Civil Engineering	16
CE4330	1	Geology I	12
CE5390	2	Geothermics	
CE4510	2	Environmental Impact Assessment	36

Institute wide Course

CE6540	3	Contaminant Hydrology And Remediation	
CE6580	3	Solid and Hazardous Waste Management	
CE6510	3	Water And Wastewater Engineering	
CE6520	3	Air Pollution	
CE6300	3	Advanced Foundation Engineering	
CE6310	3	Advanced Soil Mechanics	
CE6340	0	Ground Modification Techniques	
CE6330	3	Soil Dynamics	
CE6352	3	Design Of Earth Structures	
CE6130	3	Finite Element Analysis	
CE6222	3	Prestressed Concrete Design	
CE6120	3	Applied Elasticity And Plasticity	
CE4102	0	None	
CE6140	3	Structural Dynamics	
CE6110	3	Advanced Structural Mechanics	
CE6232	3	Advanced Steel Design	
CE6500	3	Engineering Hydrology And Hydrologic Systems	
CE6610	3	Remote Sensing and GIS Applications To Civil Engineering	
CE6530	3	Groundwater Modeling	
CE6011	2	Computer Methods In Civil Engineering	16
CE4330	1	Geology I	12
CE5390	2	Geothermics	
ME2090	2	Kinematics of Mechanisms	13
ME2100	2	Dynamics of Mechanisms	46
ME3150	2	Applied Elasticity	14
ME3413	2	Machine Drawing and Solid Modelling	16
ME2070	0	None	
ME5010	3	Mathematical Methods for Engineers	16
ME5110	3	Advanced Mechanics of Solids	
ME5120	3	Dynamics and Vibration	16
ME5700	3	Analysis and Design of Composite Structures	
ME5610	3	Fracture Mechanics	16
ME5630	3	Nonlinear Oscillation	
ME5690	3	Advanced FEM	
ME5260	3	Continuum Mechanics	16
ME5320	3	Advanced Heat Transfer	16
ME5330	3	Computational Fluid Dynamics	16
CH5050	2	Non-isothermal Reactors	
MS5100	3	Composite Materials	
MS5140	3	Introduction to Computational Methods in Materials Science	

Code	Cred.	Course Title	Segments
CE4510	2	Environmental Impact Assessment	36

3.2 Minor

Code	Cred.	Course Title
CE3512	1	Introduction To Environmental Engineering
CE3300	1.5	Geotechnical Engineering - I
CE2100	1.5	Introduction To Structural Analysis
CE4502	3	Engineering Hydrology and Water Resources Engineering

3.3 Honors

Code	Cred.	Course Title
CE6110	3	Advanced Structural Mechanics
CE6120	3	Applied Elasticity And Plasticity
CE6140	3	Structural Dynamics
CE6130	3	Finite Element Analysis
CE6232	3	Advanced Steel Design
CE6222	3	Prestressed Concrete Design

3.4 Double Major

Code	Cred.	Course Title
ID1100	2	Fluid Mechanics - I
ID1160	2	Solid Mechanics - I
ID1110	1.5	Fluid Mechanics - II
ID2020	2	Solid Mechanics - II
CE3300	1.5	Geotechnical Engineering - I
CE3310	1.5	Geotechnical Engineering - II
CE3312	1	Introduction To Foundation Engineering
CE2020	1.5	Construction Materials
CE2030	1.5	Concrete Technology
CE3102	1.5	Introduction To Reinforced Concrete
CE2110	1.5	Analysis Of Indeterminate Structures
CE3112	1.5	Introduction to Structural Steel Design
CE4900	2	Construction Management
CE3512	1	Introduction To Environmental Engineering
CE3522	2	Water And Waste Water Engineering
CE3500	1.5	Introduction to Hydraulic Engineering
CE2500	2	Engineering Hydrology
CE3800	3	Transportation Engineering 1

4 | Department of Chemical Engineering

4.1 BTech

- A total of 3 credits of Free Electives can be taken in any semester from 4th to 8th semesters

Code	Cred.	Course Title	Segments
Semester 1			
CH1010	2	Material and Energy Balances	
CH1030	2	Fluid Mechanics	
CH1050	1	Introduction to Mass Transfer	
ID1035	1	Independent Project	16
ID1054	2	Digital Fabrication	16
ID1171	2	Fabrication Lab - I	16
MA1110	1	Calculus - I	12
MA1220	1	Calculus- II (Multivariable Calculus)	34
MA1230	1	Series of Functions	56
PH1017	1	Classical Physics	34
PH1031	2	Physics Lab	16
Semester 2			
CH1020	2	Introduction to Thermodynamics	
CH1021	1	Chemical Engineering Lab	
CH1040	2	Chemical Reaction Engineering - I	
CH1060	2	Heat Transfer	
CH1080	2	Separations Process - I	
CY1020	1	Dynamics of Chemical Systems-i	12
ID4006	2	Ethics and Values	36
LAXXXX	1	LA/CA Elective	
MA1130	1	Vector Calculus	12
MA1140	1	Elementary Linear Algebra	34
MA1150	1	Differential Equations	56
PH1027	1	Electromagnetism and Maxwell's Equations	34
Semester 3			
CH2010	2	Mechanical Operations	
CH2011	1	Applied Chemistry Lab	
CH2030	2	Numerical Methods - I	
CHXXXX	3	Core Elective Basket: Biological Processes	
CY1030	2	Environmental Chemistry-ii	36
CY1017	1	Environmental Chemistry-i	12
CY1031	2	Laboratory Experiments	16
ID1041	2	Engineering Drawing	16
ID1303	2	Programming in C/C++ With Lab	
MA2120	1	Transform Techniques	
Semester 4			
CH2020	1	Basic Control Theory	
CH2021	1	Mechanical Operations Lab	

Code	Cred.	Course Title	Segments
CH2040	2	Heat Transfer Equipment and Design	
CH2060	1	Numerical Methods - II	
CH2080	2	Chemical Reaction Engineering - II	
CH2100	1	Heterogeneous Reaction Engineering	
CH2120	1	Fluid Mechanics Lab	
CHXXXX	3	Core Elective Basket: Energy and Environment	
LAXXXX	2	La-1/ca-1	
XXXXXX	0-3	Free Elective	
MA2130	1	Complex Variables	12
Semester 5			
CH3010	2	Separation Process II	
CH3011	1	HT Lab	
CH3030	2	Transport Phenomena - I	
CH3031	1	MT Lab	
CH3050	2	Control Design and Analysis	
CH3070	2	Chemical Engineering Thermodynamics - I	
CH3090	1	Chemical Engineering Thermodynamics - II	
CHXXXX	3	Core Elective Basket: Materials	
LAXXXX	2	La-2/ca-2	
XXXXXX	0-3	Free Elective	
Semester 6			
CH3020	1	Transport Phenomena - II	
CH3021	1	Reaction Engineering Lab	
CH3022	1	Mass Transfer Equipment Design	
CH3041	1	Process Control Lab	
CH3042	2	Plant Design - I	
CHXXXX	3	Core Elective Basket: Chemical Processes	
LAXXXX	2	La-3/ca-3	
XXXXXX	0-3	Free Elective	
Semester 7			
CH4011	2	Process Simulation Lab	
CH4012	1	Plant Design - II	
LAXXXX	2	La-4/ca-4	
CHXXXX	6	Department Electives I	
XXXXXX	0-3	Free Elective	
Semester 8			
CH4020	2	Optimization	
LAXXXX	2	La-5/ca-5	
CHXXXX	5	Department Electives II	
XXXXXX	0-3	Free Elective	
Biological Processes			
CH6330	1	Systems Biology	
CH6680	1	Drug Delivery Systems	
CH6160	1	Introduction to Biological Engineering	
CH4450	1	Biomechanics	
CH6250	1	Engineering Materials	
CH6310	3	Cardiovascular Mechanics	
Energy and Environment			
CH6690	2	Energy Storage Systems	
CH6020	1	Sustainable and Energy Options	
CH6610	1	Fuel Cell Technology	
CH6400	1	Biorefinery	
CE3512	1	Introduction To Environmental Engineering	12

Code	Cred.	Course Title	Segments
CE3522	2	Water And Waste Water Engineering	14
CE3530	2	Air Pollution	14
Materials			
CH6720	2	Basics of Nanosciences and Nanotechnology	
CH6710	2	Concepts in Soft Matter Systems	
CH3580	1	Introduction to Nanotechnology	
CH6720	2	Basics of Nanosciences and Nanotechnology	
CH6730	2	Nature Inspired materials engineering	
CH6250	1	Engineering Materials	
Chemical Processes			
CH1480	1	Chemical Technology	
CH2580	2	Petrochemical Industry	
CH6140	2	Petroleum Refinery	
CH6040	1	Process Intensification	
CH6550	2	Chemical Reactor Modeling	
CH6120	1	Fluidization Technology	
CH6560	1	Mineral Processing	
CH6480	2	Principles of Heterogeneous Catalysis	
CH6630	2	Membrane Separation Process	

4.2 Minor

Code	Cred.	Course Title
CHXXXX	3	Electives (5th Semester)
CHXXXX	3	Electives (6th Semester)
CHXXXX	3	Electives (7th Semester)
CHXXXX	3	Electives (8th Semester)

4.3 Honors

Code	Cred.	Course Title
CHXXXX	3	Electives (5th Semester)
CHXXXX	3	Electives (6th Semester)
CHXXXX	3	Project (7th Semester)
CHXXXX	3	Project (8th Semester)

4.4 Double Major

Code	Cred.	Course Title
CH1050	1	Introduction to Mass Transfer
CH1040	2	Chemical Reaction Engineering - I
CH1060	2	Heat Transfer
CH2010	2	Mechanical Operations
CH1080	2	Separations Process - I

Code	Cred.	Course Title
CH3010	2	Separation Process II
CH3042	2	Plant Design - I
CH3050	2	Control Design and Analysis
CHXXXX[1]	1	Elective
CH3070	2	Chemical Engineering Thermodynamics - I
CH2020	1	Basic Control Theory
CH3030	2	Transport Phenomena - I
CHXXXX[2]	1	Elective II
CH3011	1	HT Lab
CH3021	1	Reaction Engineering Lab
CH3031	1	MT Lab
CH3041	1	Process Control Lab

1. Energy and Environment basket
2. Chemical process basket

5 | Department of Computer Science and Engineering

5.1 BTech

Code	Cred.	Course Title	Segments
Semester 1			
CS1310	2	Discrete Structures I	
CYXXXX	1	CY Electives	
ID1330	1	Applied Digital Logic Desgn	12
ID1340	1	Digital System Design	34
ID1035	1	Independent Project	16
ID1054	2	Digital Fabrication	16
ID1303	2	Programming in C/C++ With Lab	
LAXXXX	1	LA/CA Elective	
MA1110	1	Calculus - I	12
MA1220	1	Calculus- II (Multivariable Calculus)	34
MA1230	1	Series of Functions	56
PHXXXX	1	PH Electives	
Semester 2			
BOXXXX	1	BO Electives	
CS1340	2	Discrete Structures II	
CS1353	3	Introduction to Data Structures	
CYXXXX	1	CY Electives	
ID1370	1	DSP	34
LAXXXX	2	LA/CA Elective	
MA1130	1	Vector Calculus	12
MA1140	1	Elementary Linear Algebra	34
PHXXXX	2	PH Electives	
XXXXXX	1	Free Electives	
Semester 3			
CS2233	3	Data Structures	
CS2323	2	Computer Architecture	
CS2400	1	Principles of Programming Languages I	
CS3510	1	Operating Systems I	
LAXXXX	2	LA/CA Elective	
MA2110	1	Introduction to Probability	12
PH1031	2	Physics Lab	16
PHXXXX	1	PH Electives	
XXXXXX	2	Free Electives	
Semester 4			
CS2410	2	Theory of Computation	
CS2420	1	Introduction to Complexity Theory	
CS2433	3	Principles of Programming Languages II	

Code	Cred.	Course Title	Segments
CS2443	3	Algorithms	
CS3320	1	Compilers I	
CS3523	3	Operating Systems II	
MAXXXX	1	MA Elective	
XXXXXX	2	Free Electives	
Semester 5			
BMXXXX	1	BM Electives	
CS3423	3	Compilers II	
CS3530	1	Computer Networks I	
CS3550	1	Introduction to Database Management Systems	
CSXXXX	3	Dept Electives	
LAXXXX	3	LA/CA Elective	
XXXXXX	5	Free Electives	
Semester 6			
CS3543	3	Computer Networks II	
CS3563	3	Database Management Systems (with Lab)	
CSXXXX	5	Dept Electives	
LAXXXX	3	LA/CA Elective	
XXXXXX	3	Free Electives	
Semester 7			
CS4443	3	Software Engineering (includes Lab)	
CSXXXX	6	Dept Electives	
LAXXXX	3	LA/CA Elective	
XXXXXX	3	Free Electives	
Semester 8			
CSXXXX	6	Dept Electives	
ID4006	2	Ethics and Values	36
LAXXXX	2	LA/CA Elective	
XXXXXX	6	Free Electives	

5.2 Minor

- **Requirements:**
  - Any 12 credits out of 23 listed in the table, starting from the 4th semester of the student from other departments.
  - Any course that is part of the student's primary majory curriculum cannot be used to count toward the CSE minor requirement.
  - The student should ensure that the prerequisites are met and manage the schedule of theses courses along with that of the home department.
  - The student should enroll with the application process which will be announced before the 4th semester. The announcement is through email and it is the interested student's responsibility to apply before the announced deadline. Note that this application process is different from registration on the AIMS portal.

Code	Cred.	Course Title
CS1353	3	Introduction to Data Structures
CS2233	3	Data Structures
EE1110	1	Applied Digital Logic Design
CS2400	1	Principles of Programming Languages I
CS2323	2	Computer Architecture
CS3510	1	Operating Systems I
CS2443	3	Algorithms

Code	Cred.	Course Title
CS3523	3	Operating Systems II
CS3530	1	Computer Networks I
CS3550	1	Introduction to Database Management Systems
CS3563	3	Database Management Systems (with Lab)

5.3 Honors

- **Requirements:** To earn honors, a student has to do 12 extra credits: 6 consisting of honors projects and 6 consisting of department electives.

Code	Cred.	Course Title
CS4025	3	Honors Project Stage 1
CS4045	3	Honors Project Stage 2
CSXXXX	6	Department Electives

5.4 Double Major

- **Requirements:**
  - At least 24 credits in the CS department which must include 15 credits out of the 23 listed in the table, starting from the 4th semester of the student from other departments.
  - Any course that is part of the student's primary majory curriculum cannot be used to count toward the CSE double major requirement.
  - The student should ensure that the prerequisites are met and manage the schedule of theses courses along with that of the home department.
  - The student should enroll with the application process which will be announced before the 4th semester. The announcement is through email and it is the interested student's responsibility to apply before the announced deadline. Note that this application process is different from registration on the AIMS portal.

Code	Cred.	Course Title
CS1353	3	Introduction to Data Structures
CS2233	3	Data Structures
EE1110	1	Applied Digital Logic Design
CS2400	1	Principles of Programming Languages I
CS2323	2	Computer Architecture
CS3510	1	Operating Systems I
CS2443	3	Algorithms
CS3523	3	Operating Systems II
CS3530	1	Computer Networks I
CS3550	1	Introduction to Database Management Systems
CS3563	3	Database Management Systems (with Lab)

6 | Department of Design

6.1 BDes

Code	Cred.	Course Title	Segments
Semester 1			
DS1013	1	Elements of Design	
DS1020	1	Design, Culture and Society	
DS1033	1	Color	
DS1043	1	Environmental Exposure	
DS1053	2	Introduction to Design (lecture Series)	
DS1063	1	Principles of Design	
DS1193	1	Design Drawing 1	
DS1070	1	Evolution of Design	
DS1083	1	Digital Fabrication 1	
DS1093	1	Form	
DS1101	3	Workshop and Material Explorations	
Semester 2			
DS1113	2	Product Design	
DS1123	2	Animation	
DS1130	2	Film Appreciation	
DS1144	2	Digital Fabrication 2	
DS1153	2	Interaction Design	
DS1163	2	Graphic Design	
DS1173	2	Photography	
DS1183	1	Design Process	
Semester 3			
DS2013	2	Material Explorations	
DS2023	1	Applied Ergonomics	
DS2033	1	Design Computing	
DS2043	1	Sound Design	
DSXXXX	0	Electives	
DS2050	1	Semiotics	
Semester 4			
DS2213	1	Design for Sustainability	
DS2223	1	Mental Model and Affordance	
DS2232	2	Illustration	
DS2243	1	Data and Information Visualization	
DS2250	1	Indian Aesthetics	
DS2263	1	Universal Design	
DSXXXX	0	Electives	
Semester 5			
DS3093	2	System Design for Sustainability	
DS3013	2	Virtual Environments in Design	
DS3113	2	Digital Storytelling	

Code	Cred.	Course Title	Segments
DS3120	2	Design and Philosophy	
DS3133	2	Digital Heritage	
DS3143	2	Design for Education	
DS3153	2	Display and Control	
DS3163	2	Documentary Photography	
DS3173	2	Moving Images	
Semester 6			
DSXXXX	0	Electives	
Semester 7			
DS4013	2	Automobile Design Explorations	
DS4023	1	Calligraphy	
DS4016	1	Internship	
DS4020	2	Design Management	
DS4030	1	Intellectual Property Rights	
DS4033	1	Life Cycle Analysis	
DS4040	1	Professional Practice	
DS4050	1	Entrepreneurship and Business Planning	
DS4060	1	Design Research	
DS4073	1	Design Innovation	
DS4080	1	Portfolio Skills	
Semester 8			
DS4115	15	Final Semester Thesis Project	
Semester 3 Electives			
DS2063	2	Advanced Product Design	
DS2073	2	Advanced Graphic Design	
DS2083	2	Automobile Design Voyage 1	
DS2093	2	Elements of Film Making	
DS2103	2	Printing Technique	
DS2113	2	Interaction Design 2	
DS2123	2	Storyboarding	
DS2133	2	Product Photography and Studio Lighting	
Semester 4 Electives			
DS2272	1	Form Language	
DS2283	2	Creative Coding	
DS2293	2	Advanced Typography	
DS2313	1	Cognitive Ergonomics	
DS2333	2	Nature and Form	
Semester 6 Electives			
DS3183	2	Automobile Design Voyage-2	
DS3193	2	Technically Complex Product Design	
DS3203	2	Participatory Design	
DS3213	2	Contemporary Photography	
DS3223	2	Advertisement and Branding	
DS3233	2	Environmental Design	
DS3243	2	Tangible Computing	
DS3253	2	AI in Design	
DS3263	2	Film Making	
DS3273	2	Product Graphics and Packaging	

7 | Department of Electrical Engineering

7.1 BTech

Code	Cred.	Course Title	Segments
Semester 1			
ID1054	2	Digital Fabrication	16
MEXXXX	2	Digital Fabrication	
MA1110	1	Calculus - I	12
MA1220	1	Calculus- II (Multivariable Calculus)	34
MA1230	1	Series of Functions	56
PH1017	1	Classical Physics	
EE1010	1	Electric Circuits	
EE1020	1	Magnetic Circuits	
EE1110	1	Applied Digital Logic Design	
EE1083	2	Introduction to Computing	
EE1350	1	Signals and Systems	
EE1320	1	Internet of Things	
ID1393	1	Introduction to Drones	
BM1030	1	Bioengineering	
LA/CA	1	LA/CA Elective	
Semester 2			
EE1025	1	Independent Project	
MA1130	1	Vector Calculus	12
MA1150	1	Differential Equations	56
EE1040*	1	Matrix Analysis	
EE1370*	2	Data Analytics	
EE1210	1	Basic Control Theory	
EE1390	1	Introduction to AI and ML	
EE1120	1	Digital System Design	
EE1360	1	Communication Systems	
EE1030	2	Network Theory and Synthesis	
EE1193	2	Introduction to Hardware Description Languages	
XXXXXX	1	Free Elective	
LA/CA	1	LA/CA Elective	
Semester 3			
EE2015	1	EE Independent Project	
CY1017	1	Environmental Chemistry-i	12
CY1031	2	Laboratory Experiments	16
EE2350	1	DSP	
EE2210	2	Transformer and DC Machines	
EE2010	2	Engineering Electromagnetics	
EE2310	1	Random Processes	
EE2133	1	Analog Electronics	
EE2187	1	Semiconductor Fundamentals	
EE2188	1	Electronic Devices and Circuits	
EE2320	1	Digital Modulation Techniques	

Code	Cred.	Course Title	Segments
LA/CA	1	LA/CA Elective	
Semester 4			
EE2025	1	EE Independent Project	
XXXXXX	1	Science Elective	
MA2130	1	Complex Variables	12
EE2220	1	AC Machines	
EE2134	2	Analog System Design	
EE2189	2	Physics of MOS Transistors	
EE2240	2	Control Systems	36
EE2370	2	Advanced DSP	
EE2211	2	Electrical Machines Lab	
EE2340	1	Information Science	
LA/CA	1	LA/CA Elective	
Semester 5			
IDXXXX	1	Independent Project	
XXXXXX	1	Science Elective	
EE3210	1	Smart Grid	
EE3220	2	Power System Practice	
EE3220	2	Power System Practice	
EE3010	2	Wave Propagation and Transmission Lines	
EE3113	2	Introduction to VLSI Design	
EE3013	2	Data Structures	
EEXXXX	3	Core Electives	
LA/CA	1	LA/CA Elective	
Semester 6			
IDXXXX	1	Independent Project	
XXXXXX	1	Science Elective	
XXXXXX	2	Engineering Elective	
EE3260	1	Renewable Energy and Power Systems	
EE3120	2	Microprocessor and Computer Architecture	
EE3320	1	Wireless Communications	
EEXXXX	3	Core Electives	
XXXXXX	3	Free Electives	
LA/CA	1	LA/CA Elective	
Semester 7			
EE4015	3	EE Independent Project	
XXXXXX	3	Science Elective	
EEXXXX	3	Core Electives	
EE4180	1	Sensor Technology for Intelligent Healthcare Systems	
XXXXXX	2	Free Electives	
LAXXXX	1	Liberal Arts Elective	
CAXXXX	1	Creative Arts Elective	
Semester 8			
EE4025	3	EE Independent Project	
EEXXXX	6	Core Elective	
XXXXXX	3	Free Elective	
ID4006	2	Ethics and Values	36
CAXXXX	1	Creative Arts Electives	

7.2 Minor

- A student opting for minors in the Dept. of EE should obtain 12 credits from the following courses. These 12 credits should be over and above any EE credits that he/she has obtained as a part of parent dept. Curriculum.

Code	Cred.	Course Title
Basket		
EE1010	1	Electric Circuits
EE1020	1	Magnetic Circuits
EE1030	2	Network Theory and Synthesis
EE1030	2	Network Theory and Synthesis
EE1110	1	Applied Digital Logic Design
EE1120	1	Digital System Design
EE1193	2	Introduction to Hardware Description Languages
EE1210	1	Basic Control Theory
EE1320	1	Internet of Things
EE1350	1	Signals and Systems
EE1360	1	Communication Systems
EE1370*	2	Data Analytics
EE1390	1	Introduction to AI and ML
EE2133	1	Analog Electronics
EE2187	1	Semiconductor Fundamentals
EE2188	1	Electronic Devices and Circuits
EE2189	2	Physics of MOS Transistors
EE2210	2	Transformer and DC Machines
EE2220	1	AC Machines
EE2240	2	Control Systems
EE2310	1	Random Processes
EE2320	1	Digital Modulation Techniques
EE2350	1	DSP

7.3 Honors

- **Requirements:** To earn honors, a student has to do 12 extra credits, spread equally over semesters 5-8

Code	Cred.	Course Title
Semester 5		
EEXXXX	3	Core Electives
Semester 6		
EEXXXX	3	Core Electives
Semester 7		
EEXXXX	3	Core Electives
Semester 8		
EEXXXX	3	Core Electives

7.4 Double Major

- Double Major requires 24 credits. In case some of the courses have been done as a part of their basic degree; the students can choose additional credits as electives from EE.
- Student to choose 14 credits from the following list
- At-least 10 credits from level EE 3 and above courses

Code	Cred.	Course Title
Basket		
EE1010	1	Electric Circuits
EE1020	1	Magnetic Circuits
EE1030	2	Network Theory and Synthesis
EE1030	2	Network Theory and Synthesis
EE1110	1	Applied Digital Logic Design
EE1120	1	Digital System Design
EE1193	2	Introduction to Hardware Description Languages
EE1210	1	Basic Control Theory
EE1320	1	Internet of Things
EE1350	1	Signals and Systems
EE1360	1	Communication Systems
EE1370*	2	Data Analytics
EE1390	1	Introduction to AI and ML
EE2133	1	Analog Electronics
EE2187	1	Semiconductor Fundamentals
EE2188	1	Electronic Devices and Circuits
EE2189	2	Physics of MOS Transistors
EE2210	2	Transformer and DC Machines
EE2220	1	AC Machines
EE2240	2	Control Systems
EE2310	1	Random Processes
EE2320	1	Digital Modulation Techniques
EE2350	1	DSP

8 | Department of Engineering Science

8.1 BTech

Code	Cred.	Course Title	Segments
Semester 1			
ID1054	2	Digital Fabrication	16
ID1303	2	Programming in C/C++ With Lab	
CS1310	2	Discrete Structures I	
ID1035	1	Independent Project	16
EE1110	1	Applied Digital Logic Design	
MA1110	1	Calculus - I	12
MA1220	1	Calculus- II (Multivariable Calculus)	34
MA1230	1	Series of Functions	56
EE1320	1	Internet of Things	
CY1017	1	Environmental Chemistry-i	12
EEXXX	1	Signals and Systems	
LAXXX	1	Liberal and Creative Arts Electives	
XXXXXX	1	Free Elective	
Semester 2			
MS1050	1	Physics of Solids	
BO1010	1	Introduction to Life Sciences	46
CS1353	3	Introduction to Data Structures	
ID1140	1	Thermodynamics - I	12
MA1130	1	Vector Calculus	12
MA1140	1	Elementary Linear Algebra	34
MA1150	1	Differential Equations	56
PH1027	1	Em and Maxwells Eqn	
CY1027	1	Dynamics of Chemical Systems-1	
EEXXXX	2	Introduction to Hdl	
PH2027	1	Quantum Physics	
LAXXXX	1	Liberal and Creative Arts Electives	
XXXXXX	1	Free Elective	
EE1120	1	Digital System Design	
Semester 3			
EE1010	1	Electric Circuits	
CY1031	2	Laboratory Experiments	16
PH1017	1	Classical Physics	
BM1030	1	Bioengineering	
ID1100	2	Fluid Mechanics - I	46
EE1140	1	Semiconductor Fundamentals	
CS2400	1	Principles of Programming Languages I	
CS2233	3	Data Structures	
CH2450	2	Numerical Methods-1	
MA2110	1	Introduction to Probability	12
LAXXXX	1	Liberal and Creative Arts Electives	
EEXXXX	1	Basic Electronics and Devices	

Code	Cred.	Course Title	Segments
Semester 4			
MA2140	1	Introduction to Statistics	34
MA2130	1	Complex Variables	12
ME2080	1	Introduction to Mathematical Modelling	12
CS2443	3	Algorithms	
CS2410	2	Theory of Computation	
ME1030	2	Dynamics	46
EE1330	1	DSP	
EE2140	1	CMOS Fabrication	
EE2240	2	Control Systems	36
LAXXXX	1	Liberal and Creative Arts Electives	
XXXXXX	1	Free Elective	
Semester 5-8			
XXXXXX	34	Core Engg Electives	
XXXXXX	9	Free Electives	
LAXXXX	6	LA/CA Elective	
XXXXXX	12	Project	

9 | Department of Liberal Arts

9.1 Minor in Economics

Code	Cred.	Course Title
Semester 3rd Year		
LA3010	3	Financial Institutions and Markets
LA5010	3	Macroeconomics
Semester 4th Year		
LA4060	3	Indian Economic Development
LA5030	3	Basic Econometrics and Forecasting

9.2 Minor in AI and Humanity

Code	Cred.	Course Title
Semester 1		
LA1470	1	Philosophical Perspectives On Human-technology Interactions
LA1480	1	Artificial Intelligence in Literature and Popular Culture
LA1490	1	Socio-cultural Perspectives On Artificial Intelligence
Semester 2		
LA1500	1	What is AI and Humanity?
LA1540	1	Artificial Intelligence and Behavioral and Mental Health
Semester 3		
LAXXXX	1	AI and Social Justice
LAXXXX	1	The AI Economy
LAXXXX	1	Governance Perspectives On AI
Semester 4		
LAXXXX	3	Project

10 | Department of Mathematics

10.1 BTech

Code	Cred.	Course Title	Segments
Semester 1			
MA1110	1	Calculus I	12
MA1220	1	Calculus II - Multivariable Calculus	34
MA1230	1	Series of Functions	56
MA1500	1	Math Foundation	34
MA1510	1	Introduction to Number Systems	56
CS1310	2	Discrete Structure-i	14
ID1054	2	Digital Fabrication	16
ID1035	1	Independent Project	
ID1303	2	Introduction to Programming	36
ID1330	1	Applied Digital Logic Design	12
PH/CY	1	Science Elective	
LA/LC	1	Electives	
Semester 2			
MA1130	1	Vector Calculus	12
MA1140	1	Elementary Linear Algebra	34
MA1150	1	Differential Equations	56
CS1340	2	Discrete Structure-ii	36
CS1353	3	Introduction to Data Structures	16
EE1210	1	Basic Control Theory	12
ID1370	1	Digital Signal Processing	56
ID1360	1	Embedded Programming	34
FE*	1	Free Elective	
PH/CY	2	Science Elective	
LA/LC	1	Electives	
Semester 3			
MA2110	1	Introduction to Probability	12
MA2120	1	Transform Techniques	34
MA4020	3	Linear Algebra	16
MA****	1	Dept Elective	
CS2233	3	Data Structures	16
CS2323	2	Computer Architecture	
CS2400	1	Principles of Programming Languages I	56
CS3510	1	Operating Systems I	56
EE2310/EE5827	1	Random Processes	56
ID1350	1	Internet of Things (iot)	12
LA/LC	1	Electives	
Semester 4			
MA2130	1	Complex Variables	12
MA2140	1	Introduction to Statistics	34
MA5060	3	Numerical Analysis	16

Code	Cred.	Course Title	Segments
MA****	1	Dept Elective	
EE5606/CS5606	2	Convex Optimization	
CS2443	3	Algorithms	16
CS2410	2	Theory of Computation	14
CS2420	1	Introduction to Complexity Theory	56
EE2340	1	Information Sciences	12
ID1050	1	AI	34
PH/CY	1	Science Elective	
Semester 5			
MA4010	3	Analysis of Functions of a Single Variable	16
MA3140	2	Statistical Inference	
MA****	3	Dept Electives	16
MA****	4	Dept Electives	16
CS3550	1	Dbms-i	56
CS3530	1	Computer Networks I	
FE*	2	Free Elective	
Semester 6			
MA4090	3	Analysis of Functions of Several Variables	16
MA4070	3	Groups and Rings	16
MA****	3	Dept Electives	16
MA****	3	Dept Electives	16
FE*	3	Free Elective	16
LA/LC	1	Professional Ethics	
Semester 7			
MA5020	3	Functional Analysis	16
MA****	3	Dept. Electives	16
MA****	3	Dept. Electives	16
FE*	3	Free Elective	16
LA/LC	3	Elective	16
Semester 8			
MA****	3	Dept Electives	16
MA****	3	Dept Electives	16
MA****	3	Dept Electives	16
LA/LC	3	Free Elective	16
LA/LC	3	Elective	16

10.2 Minor

- For a B.Tech student to obtain a minor in Math s/he needs to take 12 credits of Math courses from the list below:

Code	Cred.	Course Title
MA4010	3	Analysis of Functions of a Single Variable
MA4020	3	Linear Algebra
MA4030	3	Ordinary Differential Equations
MA4060	3	Complex Analysis
MA4070	3	Groups and Rings
MA4080	3	Measure and Integration
MA4090	3	Analysis of Functions of Several Variables
MA5010	3	Combinatorics and Graph Theory
MA5020	3	Functional Analysis
MA5030	3	Partial Differential Equations

Code	Cred.	Course Title
MA5040	3	Topology
MA5050	3	Mathematical Methods
MA5060	3	Numerical Analysis
MA5070	3	Modules and Fields
MA5080	3	Advanced Programming
MA5090	3	Sets, Logics and Boolean Algebra
MA5100	3	Introduction to Algebraic Topology
MA5110	3	Fourier Analysis and Applications
MA5120	3	Numerical Linear Algebra
MA5130	3	Theory of Computation
MA5140	3	Mathematical Introduction to Elliptic Curves
MA5150	3	Algebraic Number Theory
MA5160	3	An Introduction to Modular Forms
MA5170	3	Basic Introduction to Algebraic Geometry
MA5180	3	Advanced Measure Theory
MA5190	3	Advanced Partial Differential Equations
MA6040	3	Fuzzy Logic Connectives and Their Applications
MA6050	3	Wavelets and Applications
MA6060	3	Redundant and Sparse Representation Theory
MA6070	3	Approximation Theory
MA6080	3	Measure Theoretic Probability
MA6090	3	Operator Theory
MA6100	3	Mathematics Behind Machine Learning
MA6110	3	Convex Functions and Their Applications
MA6120	3	An Introduction to Operator Algebras
MA6130	3	Banach Space Theory
MA6140	3	Compressive Sensing
MA6150	3	Discrete Dynamical Systems
MA6160	3	Banach Algebras
MA6190	3	Transcendental Number Theory
MA6220	3	Distribution Theory and Sobolev Spaces
MA6230	3	An Introduction to Variational Methods
MA6240	3	Differential Geometry
MA6210	3	Curves and Surfaces
MA6260	3	Algebraic Geometry I
MA6270	3	Algebraic Geometry II
MA6116	3	Commutative Algebra

10.3 Double Major

- For a B.Tech student to obtain a major in Math, s/he needs to take courses worth 24 credits as prescribed below.

Code	Cred.	Course Title
MA4010[1]	3	Analysis of Functions of a Single Variable
MA4020[1]	3	Linear Algebra
MA4060[1]	3	Complex Analysis
MA4070[1]	3	Groups and Rings
MA4080	3	Measure and Integration
MA4090	3	Analysis of Functions of Several Variables
MA5010	3	Combinatorics and Graph Theory
MA5020	3	Functional Analysis
MA5030	3	Partial Differential Equations
MA5040	3	Topology
MA5050	3	Mathematical Methods

Code	Cred.	Course Title
MA5060	3	Numerical Analysis
MA5070	3	Modules and Fields
MA5080	3	Advanced Programming
MA5090	3	Sets, Logics and Boolean Algebra
MA5100	3	Introduction to Algebraic Topology
MA5110	3	Fourier Analysis and Applications
MA5120	3	Numerical Linear Algebra
MA5130	3	Theory of Computation
MA5140	3	Mathematical Introduction to Elliptic Curves
MA5150	3	Algebraic Number Theory
MA5160	3	An Introduction to Modular Forms
MA5170	3	Basic Introduction to Algebraic Geometry
MA5180	3	Advanced Measure Theory
MA5190	3	Advanced Partial Differential Equations
MA6040	3	Fuzzy Logic Connectives and Their Applications
MA6050	3	Wavelets and Applications
MA6060	3	Redundant and Sparse Representation Theory
MA6070	3	Approximation Theory
MA6080	3	Measure Theoretic Probability
MA6090	3	Operator Theory
MA6100	3	Mathematics Behind Machine Learning
MA6110	3	Convex Functions and Their Applications
MA6120	3	An Introduction to Operator Algebras
MA6130	3	Banach Space Theory
MA6140	3	Compressive Sensing
MA6150	3	Discrete Dynamical Systems
MA6160	3	Banach Algebras
MA6190	3	Transcendental Number Theory
MA6220	3	Distribution Theory and Sobolev Spaces
MA6230	3	An Introduction to Variational Methods
MA6240	3	Differential Geometry
MA6210	3	Curves and Surfaces
MA6260	3	Algebraic Geometry I
MA6270	3	Algebraic Geometry II
MA6116	3	Commutative Algebra

1. Mandatory

11 | Department of Mechanical and Aerospace Engineering

11.1 BTech in Mechanical Engineering

Code	Cred.	Course Title	Segments
Semester 1			
ID1035	1	Independent Project	16
ID1041	2	Engineering Drawing	16
ID1054	2	Digital Fabrication	16
ID1100	2	Fluid Mechanics - I	46
ID1130	2	Engineering Statics	13
ID1171	2	Fabrication Lab - I	16
LAXXXX	1	LA/CA Elective	
MA1110	1	Calculus - I	12
MA1220	1	Calculus- II (Multivariable Calculus)	34
MA1230	1	Series of Functions	56
ME1010	1	Manufacturing Technology	56
Semester 2			
BO1010	1	Introduction to Life Sciences	46
CY1021	2	Dynamics of Chemical Systems-ii	36
CY1020	1	Dynamics of Chemical Systems-i	12
ID1091	2	Fabrication Lab- II	16
ID1140	1	Thermodynamics - I	12
ID1160	2	Solid Mechanics - I	13
LAXXXX	1	LA/CA Elective	
MA1130	1	Vector Calculus	12
MA1140	1	Elementary Linear Algebra	34
MA1150	1	Differential Equations	56
ME1030	2	Dynamics	46
PH1027	1	Electromagnetism and Maxwell's Equations	56
Semester 3			
BM1030	1	Bioengineering	
CY1017	1	Environmental Chemistry-i	12
EE1010	1	Electric Circuits	
EE1110	1	Applied Digital Logic Design	
ID1110	1.5	Fluid Mechanics - II	13
ID1303	2	Programming in C/C++ With Lab	
ID2020	2	Solid Mechanics - II	46
LAXXXX	1	LA/CA Elective	
MA2110	1	Introduction to Probability	12
MA2120	1	Transform Techniques	
MS1020	1	Metallic Materials	
MS2020	2	Physical Metallurgy	
PH1031	2	Physics Lab	16

Code	Cred.	Course Title	Segments
Semester 4			
ID1150	2	Thermodynamics - II	36
LAXXXX	1	LA/CA Elective	
MA2130	1	Complex Variables	12
MA2140	1	Introduction to Statistics	34
ME2030	2	Manufacturing Science -I	36
ME2040	1.5	Instrumentation	46
ME2080	1	Introduction to Mathematical Modelling	12
ME2090	2	Kinematics of Mechanisms	13
ME2100	2	Dynamics of Mechanisms	46
ME2421	1	Solid Mechanics Lab	13
ME2431	1	Fluid Mechanics Lab	46
XXXXXX	1	Free Electives	
Semester 5			
LAXXXX	1	LA/CA Elective	
ME3010	2	Manufacturing Science - II	14
ME3070	1.5	Power and Refrigeration System	13
ME3080	2	Design of Machine Elements	13
ME3090	2	Design of Transmission Elements	46
ME3110	3	Heat and Mass Transfer	16
ME3150	2	Applied Elasticity	14
ME3445	1	Finite Element Methods Lab	13
ME3455	1	Computational Fluid Dynamics Lab	46
MEXXXX	3	Core-electives	
Semester 6			
LAXXXX	1	LA/CA Elective	
ME3060	1	Experimental Testing Techniques	56
ME3100	2	Modeling and Simulation	14
ME3140	3	IC Engines	16
ME3413	2	Machine Drawing and Solid Modelling	16
ME3425	3	Mini-project	16
ME3465	1	Manufacturing Lab	13
ME3475	1	IC Engines Lab	46
ME4030	1	Operations Research	12
ME4040	1	Industrial Engineering	34
ME4050	1	Production Planning and Control	56
Semester 7			
LAXXXX	0-1	LA/CA Elective (total 3 for 7 and 8 Sems)	
ME3040	1.5	Mathematical Elements for Geometrical Modeling	13
ME3050	1.5	Computer Integrated Manufacturing	46
ME4010	1.5	Control Systems	13
ME4020	3	Turbo Machines	16
MEXXXX[1]	3	Elective Project / Core-elective	16
ME4435	1	Dynamics Lab	13
ME4445	1	Heat Transfer Lab	46
MEXXXX	0-3	Core-electives (total 9 for 7 and 8 Sems)	
XXXXXX	0-1	Free Electives (total 2 for 7 and 8 Sems)	
Semester 8			
ID4006	2	Ethics and Values	36
LAXXXX	2-3	LA/CA Elective (total 3 for 7 and 8 Sems)	
MEXXXX	6-9	Core-electives (total 9 for 7 and 8 Sems)	
XXXXXX	1-2	Free Electives (total 2 for 7 and 8 Sems)	

1. Students can either take elective project (ME4325) or 3 credits of Core-Elective. Students enrolled for Honours project do not have elective project option and must take 3 credits of core-elective only.

11.2 Minor in Aerospace Engineering

Code	Cred.	Course Title
AE3010	1.5	Introduction to Aerospace Vehicles
AE3030	1.5	Flight Mechanics
AE3020	3	Aerodynamics
AE3050	1.5	Aircraft Propulsion
AE3070	1.5	Rocket Propulsion
AE3040	3	Aerospace Structures

11.3 Honors

Code	Cred.	Course Title
MEXXXX[1]	3	Core-electives
MEXXXX[2]	3	Core-electives
ME4705[3]	3	Honour's Project Stage-1
ME4805[4]	3	Honour's Project Stage-2

1. Semester-5
2. Semester-6
3. Semester-7
4. Semester-8

11.4 Double Major

Code	Cred.	Course Title
Dual Degree Requirements		
ME2060	1	IC Engines - I
ME2030	2	Manufacturing Science -I
ME2220	4	Kinematics and Dynamics of Machinery
ME2421	1	Solid Mechanics Lab
ME2431	1	Fluid Mechanics Lab
ME3010	2	Manufacturing Science - II
ME3130	4	Design of Machine Elements
ME3110	3	Heat and Mass Transfer
ME3465	1	Manufacturing Lab
ME4435	1	Dynamics Lab
ME4445	1	Heat Transfer Lab
MEXXX0	3	Electives
Pre-requisites expected to be completed		
ID1130	2	Engineering Statics
ID1100	2	Fluid Mechanics - I
ME1010	1	Manufacturing Technology
ID1160	2	Solid Mechanics - I
ID1140	1	Thermodynamics - I
ID1150	2	Thermodynamics - II
ID1110	1.5	Fluid Mechanics - II
ID2020	2	Solid Mechanics - II

11.5 Dual Degree (BTech + MTech)

- The total credit required will be 45 additional thesis credits to that of the BTech counterparts
- The coursework requirements till 8th semester remains same as BTech counterparts, except replacement of 8credits of core-electives and freeelectives in the 8th semester with specilization specific core-courses.

Code	Cred.	Course Title
Summer 8-9		
ME5935	5	Dual Degree Thesis (stage-1)
Semester 9		
ME5945	18	Dual Degree Thesis (stage-2)
Semester 10		
ME5955	22	Dual Degree Thesis (stage-3)

12 | Department of Materials Science and Metallurgical Engineering

12.1 BTech

Code	Cred.	Course Title	Segments
Semester 1			
CY1031	2	Laboratory Experiments	16
ID1035	1	Independent Project	16
ID1054	2	Digital Fabrication	16
ID1303	2	Programming in C/C++ With Lab	
LAXXXX	1	LA/CA Elective	
MA1110	1	Calculus - I	12
MA1220	1	Calculus- II (Multivariable Calculus)	34
MA1230	1	Series of Functions	56
MS1010	1	Science and Engineering of Materials	
MS1040	1	Materials Synthesis	
PH1017	1	Classical Physics	34
PH1031	2	Physics Lab	16
Semester 2			
BO1010	1	Introduction to Life Sciences	46
CY1021	2	Dynamics of Chemical Systems-ii	36
CY1020	1	Dynamics of Chemical Systems-i	12
LAXXXX	2	LA/CA Elective	
MA1140	1	Elementary Linear Algebra	34
MA1130	1	Vector Calculus	12
MS1011	1	Metallography Lab	13
MS1021	1	Materials Synthesis Lab	46
MS1050	1	Physics of Solids	
MS1060	1	Polymers	
MS1080	1	Computational Methods in Materials Science I	
PH1027	1	Electromagnetism and Maxwell's Equations	56
PH2027	1	Quantum Physics	34
Semester 3			
BM1030	1	Bioengineering	
CY1017	1	Environmental Chemistry-i	12
EE1010	1	Electric Circuits	
EE1020	1	Magnetic Circuits	
ID1041	2	Engineering Drawing	16
ID1171	2	Fabrication Lab - I	16
LAXXXX	2	LA/CA Elective	
MS1020	1	Metallic Materials	
MS1030	1	Materials Characterization I	
MS1070	1	Semiconductor Materials	
MS2010	1	Soft Matter Science	

Code	Cred.	Course Title	Segments
MS2020	2	Physical Metallurgy	
MS2040	2	Advanced Materials Synthesis	
MA2110	1	Introduction to Probability	12
Semester 4			
ID1160	2	Solid Mechanics - I	13
LAXXXX	2	LA/CA Elective	
MS3080	2	Computational Methods in Materials Science II	
MA2140	1	Introduction to Statistics	34
MA1150	1	Differential Equations	56
MS2011	2	Functional Properties Characterization Lab	16
MS2030	2	Materials Characterization II	
MS2050	2	Mechanical Behaviour of Materials	
MS2060	2	Functional and Structural Polymers	
MS2080	1	Process Metallurgy	
MS2090	1	Electronic Materials	
MS2100	1	Rate Phenomena in Process Metallurgy	
Semester 5			
LAXXXX	2	LA/CA Elective	
ME1010	1	Manufacturing Technology	56
MS3010	1	Magnetic Materials	
MS3020	2	Casting and Solidification	
MS3021	1	Foundry and Solidification Lab	46
MS3030	1	Non-ferrous Extractive Metallurgy	
MS3090	1	Phase Equilibria	
MS3100	2	Kinetics of Materials	
MS3270	1	Iron Making and Steel Making	56
MS3280	1	Powder Metallurgy Processing	34
MS2021	2	Mechanical Behaviour Lab	
XXXX	2	Core Elective	
XXXX	1	Free Elective	
Semester 6			
ME2030	2	Manufacturing Science -I	36
MS3011	2	Heat Treatment Lab	16
MS3015	2	Mini Project	16
MS3040	2	Thin Films	
MS3110	2	Transport Phenomena	
MS3120	2	Phase Transformations	
MS3140	1	Technical Communication	
MS3150	1	Corrosion	
XXXX	2	Core Elective	
XXXX	1	Free Elective	
Semester 7			
LAXXXX	2	LA/CA Elective	
MS3015	2	Mini Project	16
MS4011	1	Metal Forming Lab	13
MS4020	1	Research Methodology	
MS4030	1	Materials Selection and Design	
MSXXXX	4	Core Elective	
XXXXXX	1	Free Elective	
Semester 8			
MS4016	1	Seminar	56
MS4050	2	Fatigue and Fracture	
MS4060	2	Thermo-mechanical Processing	
MSXXXX	4	Core Elective	

Code	Cred.	Course Title	Segments
XXXXXX	2	Free Elective	
Electives			
MS2070	1	Ceramics and Refractories	
MS3050	1	Iron Making	
MS3060	1	Steel Making	
MS3070	2	Powder Metallurgy	
MS3240	2	Metal Joining	
MS3290	2	Crystallography -I	
MS4070	1	Introduction to Nanofabrication	
MS4090	1	Wear and Tribology	
MS4140	2	Applications of Electrochemistry in Materials Science and Engineering	
MS4150	1	High Entropy Materials	
MS4170	2	Introduction to Functional Ceramics	
MS4190	2	Recent Developments in 2d Materials Science	
MS4200	2	Composites	
MS4210	2	Fundamentals of Plasmonics	
MS5150	2	Biomaterials- Materials in Medicine	

12.2 Minor

- In addition to the courses listed below, 5 more credits of electives can be taken from any of the department courses.

Code	Cred.	Course Title
MS2030	2	Materials Characterization II
MS1020	1	Metallic Materials
MS2020	2	Physical Metallurgy
MS1040	1	Materials Synthesis
MS1050	1	Physics of Solids

12.3 Honors

Code	Cred.	Course Title
MS3025	3	Honors Project-i
MS4015	4	Honors Project-ii
MS4025	5	Honors Project-iii

12.4 Double Major

- In addition to the courses listed below, 5 more credits of electives can be taken from any of the department courses.

Code	Cred.	Course Title
MS1020	1	Metallic Materials
MS1030	1	Materials Characterization I
MS1040	1	Materials Synthesis

Code	Cred.	Course Title
MS2010	1	Soft Matter Science
MS2020	2	Physical Metallurgy
MS1070	1	Semiconductor Materials
MS3090	1	Phase Equilibria
MS3100	2	Kinetics of Materials
MS4030	1	Materials Selection and Design
MS3021	1	Foundry and Solidification Lab
MS1050	1	Physics of Solids
MS2080	1	Process Metallurgy
MS2090	1	Electronic Materials
MS1011	1	Metallography Lab
MS1021	1	Materials Synthesis Lab
MS2011	2	Functional Properties Characterization Lab

13 | Department of Physics

13.1 BTech

Code	Cred.	Course Title	Segments
Semester 1			
ID1054	2	Digital Fabrication	16
ID1035	1	Independent Project	16
EP1567	1	Maths for Physics - I	12
MA1220	1	Calculus- II (Multivariable Calculus)	34
MA1230	1	Series of Functions	56
EP1017	1	Classical Physics	16
ID1303	2	Programming in C/C++ With Lab	
ID1310	1	Electric Circuits	36
ID1320	1	Magnetic Circuits	12
MA1110	1	Calculus - I	12
XXXXXX	2	Free Elective	34
ID1340	1	Digital System Design	
ID1330	1	Applied Digital Logic Design	
EP2217	1	Classical Electromagnetism	12
ID1393	1	Introduction to Drones	
Semester 2			
EP1587	1	Tensors and Differential Forms	36
EE1040	1	Matrix Analysis	34
CS1353	3	Introduction to Data Structures	
CY1020	1	Dynamics of Chemical Systems-i	12
EP1027	1	Electromagnetism and Maxwell Eqn	
EP2817	1	Modern Physics	34
EP2827	1	Thermodynamics	
EP2027	1	Quantum Physics	34
XXXXXX	3	Free Elective	
LAXXXX	2	LA/CA	
Semester 3			
CS2233	3	Data Structures	
EE2133	1	Analog Electronics	
EE3113	2	Introduction to VLSI Design	
EE2350	1	DSP	
EE2230	1	Power Electronics	56
CY1031	2	Laboratory Experiments	16
EP1031	2	BTech Physics Lab	16
EP2117	1	Photonics	12
EP2017	1	Relativity	16
MEXXX/ID	2	Fluid Mechanics	
EP3288	2	Analytical Mechanics	56
Semester 4			
EE2134	2	Analog System Design	

Code	Cred.	Course Title	Segments
XXXXXX	3	Free Elective	56
CS2440	3	Algorithm	12
EP2127	1	Astroparticle Physics	34
EP3317	1	Statistical Physics - I	
EP2041	2	Engineering Physics Lab - I	
LAXXXX	2	LA/CA	
Semester 5			
EE2137	1	Analog Electronics-ii	
EE2188	1	Electronic Devices and Circuits	
PH3117	1	Wave Formalism of Quantum Mechanics	
PH3127	1	Hydrogenic Atoms	14
PH3267	1	Symmetries in Quantum Mechanics	
PH3367	1	Experimental Techniques- I	56
PH2177	1	Linear Vector Spaces	
PH2187	1	Fourier Series and Integral Transforms	
PH2197	1	Complex Analysis	
PH3227	1	Nonlinear Dynamics	
PH3095	2	Project	
PH3051	2	Engineering Physics Lab - II	
EP2218	2	Electrodynamics	36
Semester 6			
EE2189	2	Physics of MOS Transistors	
PH2287	1	Special Functions and Differential Eqn	
PH2297	1	Group Theory	
PH3257	1	Numerical Methods	
PH3237	1	Approx Methods in Quantum Mechanics	
PH3277	1	Relativistic Quantum Mechanics	
PH3337	1	High Energy Physics	
PH3347	1	Crystal Structure	
PH3348	2	Statistical Mechanics - II	
PH3338	2	Photonics and Laser	14
PHXXXX	2	Core Elective	
PH4075	3	Project	
PH3061	2	Engineering Physics Lab - III	
Semester 7			
PH4268	2	Solid State Physics	
PH3478	2	Particle Physics	
PH3287	1	Atomic and Mol Phys	
PH3537	1	Nuclear Physics	
PH3358	2	Spectroscopy	
PHXXXX	2	Core Elective	
PH3027	2	Accelerator Physics	
PHXXXX	2	Core Elective	
PH4071	2	Engineering Physics Lab - IV	
LAXXXX	2	LA/CA	
Semester 8			
XXXXXX	2	Free Elective	
PHXXXX	2	Core-electives	
PHXXXX	2	Core-electives	
LAXXXX	1	Professional Ethics	
XXXXXX	2	LA/CA	
Electives			
EP1017	1	Classical Physics	
EP2217	1	Classical Electromagnetism	

Code	Cred.	Course Title	Segments
EP2117	1	Photonics	
EP2017	1	Relativity	
EP1027	1	Electromagnetism and Maxwell Equations	
EP2817	1	Modern Physics	
EP2027	1	Quantum Physics	
EP2127	1	Astroparticle Physics	

13.2 Minor

Code	Cred.	Course Title
Semester 5		
EP3117	1	Wave Formalism of Quantum Mechanics
EP3127	1	Hydrogenic Atom
EP3237	1	Approximation Methods in Quantum Mechanics
Semester 6		
EP3287	1	Atomic-molecular Physics
EP3337	1	High Energy Physics
EP3347	1	Crystal Structure
Semester 7		
EP3537/EP6327	1	Nuclear Physics
EP4268	2	Solid State Physics
Semester 8		
EPXXXX	3	Project / Minor-elective

13.3 Honors

Code	Cred.	Course Title
Semester 5		
EPXXXX	1	Elective
EP3257	1	Numerical Methods
Semester 6		
EPXXXX	1	Elective
EPXXXX	3	Elective
Semester 7		
EPXXXX	3	Departmental Project
Semester 8		
EPXXXX	3	Departmental Project

13.4 Double Major

Code	Cred.	Course Title
EP3127[1]	1	Hydrogenic Atoms
EP3117[1]	1	Wave Formalism of Qm
EP3237[1]	1	Approx. Methods in Qm
EP3317	1	Thermal Physics
EP3338[2]	2	Laser and Photonics
EP4268[3]	2	Solid State Physics
EP3478[4]	2	Particle Physics
EPXXXX	2	Elective I
EP3257[5]	1	Scattering Theory
EP3267[5]	1	Symmetries in Qm
EP3277[6]	1	Relativistic Qm
EP3347	1	Crystal Structure
EP3348[7]	2	Statistical Physics
EPXXXX	2	Elective II
EPXXXX	2	Elective III
EPXXXX	2	Elective IV

1. Pre-Requisites: EP2027
2. Pre-Requisites: EP2117 and EP1027 (1)
3. Pre-Requisites:EP3347 (1)
4. Pre-Requisites:EP2127 (1)
5. Pre-Requisites:EP3117 (1)
6. Pre-Requisites:EP3237 (1)
7. Pre-Requisites:EP3317 (1)

14 | Course Descriptions

14.1 Institute-wide Courses

ID1035 **1**
Independent Project

A project with a teamwork ensuring active individual participation, work towards a goal under fixed timeline and budget, encourage for novelty and originality in project work (while respecting practical limitations), showcasing work/product to a wide audience, demonstration of project for evaluation.

ID1041 **2**
Engineering Drawing

Introduction to engineering drawing - lettering - coordinate axes and types of views - orthographic sketching - dimensioning - sectioning - isometric sketching - boolean operations on 3D sketches.

ID1050 **1**
Introduction to AI

Game playing, speech technologies, natural language processing, computer vision,

ID1054 **2**
Digital Fabrication

Complete process chain for design and subsequent realization of concepts making use of 3D modelling and additive manufacturing (3D printing) processes: Familiarization with 3D solid modelling for creation of engineering and freeform geometries; 3D Scanning using CMM and laser scanners. 3D Printing concepts for conversion of CAD model into real part: slicing, effect of part orientation. Project involving ideation, design and final fabrication using 3D printing.

ID1091 **2**
Fabrication Lab- II

Machine Shop - Introduction to general machines, Facing, Step turning, Drilling, Knurling, Boring, Taper turning, Thread Cutting (only Demo): Welding - TIG Welding (Butt Joint with S.S.Plate), MIG welding (Butt Joint with M.S.Plate): Pneumatics Lab - Circuits and applications: Advance Electronics - Microprocessor Programming and Applications.

ID1100 **2**
Fluid Mechanics - I

Introduction - scope and relevance; Method of analysis - system vs control volumes - differential vs integral approach, Units and dimensions; 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, Atmosphere as a fluid; Fluid Concepts - Streamlines, streaklines, pathlines, viscous vs inviscid flows, laminar vs turbulent flows, compressible vs incompressible flows; Engineering bernoulli equation; Control Volume analysis: Basic laws - Mass conservation law, thermodynamic laws, Newton's laws, Angular-Momentum principle; Buckingham Pi-theorem; Similitude and modeling - scaling effects; Flows in a pipes and channels - friction factor, flow measurement devices - Venturi meter, Orifice meter.

ID1110 **1.5**
Fluid Mechanics - II
▷ID1100

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.

ID1130 **2**
Engineering Statics

Particle, deformable and rigid bodies, statics, dynamics, fundamental laws of mechanics, parallelogram law and triangular law, vector operations; Resultant of coplanar and concurrent forces; Components of forces in space; Equilibrium of a particle and a rigid body.
Trusses, Frames and Machines, analysis of forces in trusses using the method of joints and the method of sections; Special conditions in truss members: zero-force members;

Condition of statically determinate system; Force analysis in frames and machines. Internal forces-normal or axial force, shear force, bending moment, torsional moment; Sign convention for different internal forces; Application of the method of sections to determine internal forces; Relationship between applied load, shear force, and bending moment; Method of superposition to obtain shear force diagram and bending moment diagram.
Friction: Introduction to the concept of dry friction, Equilibrium of rigid bodies subjected to dry friction; Examples demonstrating the application of frictions on wedges, screws, belts, and bearings; Concept of rolling resistance.
Center of gravity and centroid; Moment of inertia; Theorems of Pappus and Guldinus; Moment of inertia for simple geometries; Parallel-axis theorem; Perpendicular-axis theorem; Polar moment of area; Radius of gyration; Application to Composite areas; Mass moment of inertia.

ID1140 **1**
Thermodynamics - I

State of a system, 0th law, equation of state; First law - Work, heat, Internal energy; Expansion work; quasi-static and reversible processes; Open and Closed systems, Enthalpy, Adiabatic changes; Carnot cycle; Second law - Entropy and the Clausius inequality; Entropy and irreversibility; Thermodynamic table and charts.

ID1150 **2**
Thermodynamics - II
▷ID1140

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.

ID1160 **2**
Solid Mechanics - I
▷ID1130

Introduction - Mechanical behaviour of materials, tension, compression and shear stresses, axially loaded members, torsion, beam bending, transverse shear, combined loading, and impact loading.

ID1171 **2**
Fabrication Lab - I

Fitting Shop - Dovetail Fitting, V-fitting, U T fit, Joining two pieces (male and female): Welding - Single V-butt joint, Double lap Joint, Corner joint, T- joint, Edge joint, Gas cutting (Demo): Machine Shop - Facing and Longitudinal turning, Step and taper turning, Chamfering and drilling: Electronics Shop - Diode characteristics, Bridge rectifier, LDR Circuit, Connecting resistors: Electrical Shop - Wiring basics, Stair case wiring, Switch circuits, Characteristics of DC motor.

ID1303 **2**
Programming in C/C++
With Lab

Introduction to C and C++ programming. Problem solving and algorithms. Input and output operations, decision control structure, loop control structure, arrays, strings, etc. Pointers, arrays, structures, functions, file operations, classes, object oriented programming.
Lab is also included in this course.

ID2020 **2**
Solid Mechanics - II
▷ID1160

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

ID4006 **2**
Ethics and Values

The primary objective of this course is to sensitize students on the concept of Ethics and Values and make them understand the relevance of these ideas in their day to day personal and professional lives. The following is the outline of the course:
- Defining Values and Ethics
- Personal and social values
- Theories on Ethics
- Ethical decision making
- Managerial Ethics and Corporate Social Responsibility

14.2 Department of Artificial Intelligence

AI1001 **1**
Introduction to Modern AI

This course provides a high level overview of the foundational principles that drive AI-based technologies. Topics to be introduced include - concepts of modelling, inference and learning; Linear and nonlinear models, supervised and unsupervised learning, classification, regression and multi layer perceptions, SVMs; state based models, Markov decision processes, games, Bayesian networks; constraint satisfaction and logic; example applications.

AI1002 Introduction to Drones	**1**	Introduction to UAVs/Drones, Drone Applications, Working Principle and Design, Inertial Measurement Unit, Sensors and Calibration, PID - Implementation and Tuning, Flight controller,Remote Controller, Quadcopter dynamics, Hands-on project - Precautions while assembling, Exercise based on Different Flight controller boards like Ardupilot APM 2.x, 3.x, hobby king KK 5.0, CC3D, Pixhawk, etc.
AI1003 Probability and Random Variables	**2**	Introduction to probability and random variables; pmf, pdf, cdf, mean and variance, examples and modelling using random variables; Markov and Chebyshev inequalities, Chernoff bounds; introduction to estimation (LMSE, MMSE and MLE)
AI1101 Linear Algebra	**3**	Modeling using matrices, basic matrix operations, row/column spaces and rank, matrix types, underdetermined/overdetermined systems of linear equations, block matrices. Matrix decompositions, quadratic forms, determinants, characteristic polynomial and its properties. Least squares and its many variants, pseudo inverse, matrix norms, generalized eigenvectors and Jordan form. Solutions to systems of ordinary differential equations, matrix exponent. Numerical issues and common matrix algorithms, linear algebra in MATLAB/python
AI2001 Basics of Machine Learning	**3**	Classification and regression using linear and nonlinear models, Bayes decision theory, risk minimization, multilayer perceptron and support vector machines. Unsupervised learning. Bayesian networks, undirected graphical models and their temporal extensions, exact and approximate inference methods, parameter estimation.
AI2002 Artificial Intelligence	**2**	Search strategies, Games and adversarial search, constraint satisfaction, propositional logic and inference, probabilistic reasoning, sequential decision problems
AI2003 Stochastic Processes	**1**	Random processes, stationarity and ergodicity, power spectral density; Markov chains, Markov decision processes and Poisson point processes.
AI2004 IoT	**1**	Introduction; architecture, node structure and networking; communication technologies and standards; smartness; fabricating electronics; hands-on projects
AI2101 Deep Learning	**3**	Deep feedforward networks, regularization for deep networks, optimization for training deep models, convolutional neural networks, recurrent neural networks, practical methodology and applications, advanced topics (Generative Adversarial Networks, Variational Autoencoders, etc)
AI2102 Reinforcement Learning	**2**	Markov decision processes, policy search, policy and value iteration; Monte carlo, Q learning, SARSA; exploration vs exploitation; function approximation, deep reinforcement learning; multi agent systems
AI3001 Robotics	**2**	Introduction to robotics; kinematic representations and transformations, dynamics techniques; trajectory planning and control.
AI3002 Introduction to Brain and Neuroscience	**1**	This course is an undergraduate's introduction to the fascinating world of the brain and its study. The course will give an overview of the structure and function of the brain along with the nervous system using interesting case studies and descriptions of experiments. Students will be introduced to various disciplines that go under the umbrella term of neurosciences like Cognitive, behavioral, network, cellular, developmental or computational neurosciences. The course will emphasize on the interdisciplinary nature of modern neuroscience and opportunities for people from various backgrounds to contribute to it. Towards the end of the course students pick a landmark paper or case study and present the same in class.
AI3003 Principles of Industry 4.0	**1**	Interconnection of sensors, communication and processing; CPS, IoT, data analytics and cloud computing; cybersecurity, autonomy and decentralization
AI3101 Data Visualization	**1**	Data visualization and exploratory data analysis, examples in python and R
AI3102 Sequence Models	**1**	Markov models, Hidden Markov models, Kalman filters, Linear Dynamical Systems, Recurrent and Recursive Neural Networks (RNNs), LSTMs, BLSTMs, Sequence-to-Sequence learning
AI3103	**2**	Bayesian data analysis seek to fit a probability distribution over the data and summarise

Bayesian Data Analysis	the results by a probability distribution on the parameters of the model and on unobserved quantities. Bayesian models allow the incorporation of prior information and domain knowledge which helps to better model the data and observations. This is especially useful for domains with limited data availability. The course will cover various topics on Bayesian data analysis such as single and multi-parameter models, hierarchical models, generalised linear models, spatio-temporal models, Bayesian decision theory, Model selection, Inference algorithms based on Monte Carlo methods, Laplace approximation, variational inference, and expectation propagation, Bayesian non-parametric approaches such as Gaussian processes and Dirichlet processes, Point processes, Bayesian optimisation, Probabilistic programming tools such as Stan and BUGS.
AI5000 **3** Basics of Machine Learning	Classification and regression using linear and nonlinear models, Bayes decision theory, risk minimization, multilayer perceptron and support vector machines. Unsupervised learning. Bayesian networks, undirected graphical models and their temporal extensions, exact and approximate inference methods, parameter estimation.
AI5001 **1** Introduction to Modern AI	This course provides a high level overview of the foundational principles that drive AI-based technologies. Topics to be introduced include - concepts of modelling, inference and learning; Linear and nonlinear models, supervised and unsupervised learning, classification, regression and multi layer perceptions, SVMs; state based models, Markov decision processes, games, Bayesian networks; constraint satisfaction and logic; example applications.
AI5002 **2** Probability and Random Variables	Introduction to probability and random variables; pmf, pdf, cdf, mean and variance, examples and modelling using random variables; Markov and Chebyshev inequalities, Chernoff bounds; introduction to estimation (LMSE, MMSE and MLE)
AI5003 **1** Stochastic Processes	Random processes, stationarity and ergodicity, power spectral density; Markov chains, Markov decision processes and Poisson point processes.
AI5005 **3** Advanced Data Structures and Algorithms	Review of basic concepts; Dictionaries – Binary search trees, Probabilistic analysis of BST, Balanced search trees, Skip lists; Universal hash family, Hash tables; Heaps, Priority queues, Algorithmic Design Paradigms- Greedy algorithms, Dynamic programming, Divide and conquer; Sorting, Randomized algorithms, Average case analysis, Lower bounds, Amortized Analysis, Graph algorithms- DFS, BFS, Topological sorting, Spanning trees, Shortest paths, Bipartite matching, Introduction to advanced algorithms – Online and Approximation algorithms.
AI5010 **2** Machine Diagnostics	Maintenance Principles; Failure Modes Effects and Criticality Analysis; Time and frequency Domain Signal Analysis; Basics of Instrumentation; Noise Monitoring
AI5100 **3** Deep Learning	Deep feedforward networks, regularization for deep networks, optimization for training deep models, convolutional neural networks, recurrent neural networks, practical methodology and applications, advanced topics (Generative Adversarial Networks, Variational Autoencoders, etc)
AI5110 **2** Big Data - Tools and Techniques	Distributed File Systems; Hadoop, MapReduce and Spark; Algorithms for Big Data, PageRank ; Bottlenecks in parallel computing

14.3 Department of Biomedical Engineering

BM1030 **1** Bioengineering	None
BM1047 **1** Neuromuscular Physiology	This course is intended for basic understanding of human physiology with respect to peripheral neurons and muscles in the engineers' perspective. The students need to understand the cellular and physiological systems with respect to peripheral neurons, neuromuscular junction and skeletal muscles. Action potential and electrical conductivity of peripheral neurons will be covered. Syllabus: Peripheral neurons and their function, Skeletal muscle and their functions, Action potential and electrical conductivity, Neuro-muscular junction

BM1050 **1**
Brain Machine Interface

This course is intended for understanding the emerging field of Brain Machine Interfaces (BMI). After the completion of this course the students will have working knowledge of what BMIs are, how they are designed, implemented and tested. The core modules of BMI are data acquisition, decoding and application. Each of these modules will be expanded in detail. The students are expected to choose a specialized topic and write a term paper towards the final week.
Syllabus: Neural Data Acquisition, Neural Decoding, Applications of Brain Machine Interfaces, Challenges and opportunities in BMIs.

BM1060 **1**
Introduction to the Brain and Neuroscience

This course is an undergraduate's introduction to the fascinating world of the brain and its study. The course will give an overview of the structure and function of the brain along with the nervous system using interesting case studies and descriptions of experiments. Students will be introduced to various disciplines that go under the umbrella term of neurosciences like Cognitive, behavioral, network, cellular, developmental or computational neurosciences. The course will emphasize on the interdisciplinary nature of modern neuroscience and opportunities for people from various backgrounds to contribute to it. Towards the end of the course students pick a landmark paper or case study and present the same in class.
Syllabus: Introduction, Organization of the brain and its function, Behaviour and cognition, Systems: Motor, sensory and learning, Regions, Networks, Neuron, Ion channels. Neural development and disease, Role of experiments and computation in neuroscience, Methods in neuroscience, The interdisciplinary nature of neuroscience.

BM4190 **2**
Biofabrication

The aim of this course is to provide insight of prospects of 3D bioprinting and allied technologires in biomedical and pharmaceutical applications. It will provide the basics and mechanisms of 3D bioprinting, 3D design software, and 3D tissue/organ printing. In addition, it will also provide nitty gritty of various biofabrication processes, such as the selection and development of biomaterial formulation (bioinks), modulating properties of biomaterials, and controlling different processing conditions. Finally, it will provide state-of-the-art examples of translation of biofabricated products from bench towards the bedside.
In this elective course, students will be introduced to all topics within biofabrication and bioprinting to provide them with a broad basic knowledge on the theoretical background, current status and future perspectives of the field. Besides the theoretical parts, students will work in teams on literature presentations. They will also prepare, present and defend a short scientific presentation.
This course will cover the basics of various 3D bioprinting techniques used in biofabrication; processing of medical imaging data into printable CAD models, and fabricating models on a 3D bioprinter; development of suitable bioinks; critical parameters of bioink for biofabrication; various process parameters and their role in biofabrication; Various 3D bioprinted in vitro, in vivo and ex vivo research models and techniques; in vitro manipulation of cells and biomaterials with a bioprinter to engineer tissues for regenerative medicine or in vitro models; biofabrication-based strategy from bench-to-bed to address a specific clinical problem; ethical issue related to biofabrication.

BM5013 **2**
Sensors and Transducers in Health Care

This course is intended to understand the origin of signals in biosystems and living organisms, their sensing, detection and meaningful processing for practical diagnostic sensing applications. Various engineering aspects of the detection, acquisition, processing, and display of signals, biomedical sensors for measurements of biopotentials, ECG, force, displacement, blood pressure and temperature sensors, will be addressed in this course. The course includes work involving circuits, electronics, sensor design and interfaces for building complete biomedical instrumentation.
Displacement sensors: Resistive sensors, strain sensors, bridge circuits, Inductive, capacitive, piezo-electric sensors
Temperature sensors: thermoelectric, radiation thermometry, thermistors, fiber-optic sensors
Biopotentials: Origin of biopotentials, Cell, nerve and muscle protentials, Action potential, resting potential, Membrane structure and Nernst Equation, Nerve cell, Biopotential electrodes and biopotential amplifiers, ECG principle, sensing, 12-Lead ECG PQRS characteristics.

BM5040 **1**
Biomechanics

Introduction to concept of stress/strain and elasticity - Normal and Shear stress - Linear models - Isotropic and Anisotropic materials - Matrix formulation to solve problems of elasticity - Biomechanics of body joints (knee and ankle) - Soft tissue mechanics and Introduction to non - linear models

BM5060 **0.5**
Cellular Physiology

- Cell structure and its organelles
- Cell membrane

	• Cell homeostasis • Nucleus structure and function of its different components
BM5070 **1.5** Systems Physiology	• Respiratory: anatomy, gas exchange, acid-base balance • Renal: anatomy, ion exchange, transport of metabolites • Gastro-intestinal tract: anatomy, absorption of micro-nutrients, dysfunction • Cutaneous system: anatomy, temperature regulation • Endocrine: basic function, major endocrine organs and their regulation, bone physiology
BM5090 **2** Biomaterials: Materials in Medicine	This course is for PhD and M. Tech students. The primary objective of this course is to teach the fundamental properties of different type of materials and their use in the human body. Student will learn the different material properties necessary for the use in biomedical application of the verities of materials. This course will help student to design a novel biomaterial for the specific application.
BM5110 **1** Lab On Chip	Introduction to Micro Nano scale phenomena - Biochips and Microfluidic Technology - Analogy with electrical circuits - Simple modeling designs - Electrokinetic manipulation of cells and macromolecules (Proteins/DNA) - Introduction to Micro Nano fabrication - Applications of Immunoassay On Chip - Outline and overview of Single cell Nanobiology on Chip.
BM5193 **2** Product Design and Prototyping	The aim of this theory course is to provide insight of designing and prototyping of medical device. It will provide the basics and mechanisms of rapid prototyping, 3D design software, and 3D printing of prototype. In addition, it will also provide hands on training of various product designing and fabrication, such as the selection and development of material formulation, optimization of different processing conditions of the printing operation, and finally 3D printing of device prototype. In this elective course, students will work in teams on a mini-project. They will select one medical device from the market, reverse engineer that and build a prototype of the same device. They will also prepare, present and defend a short scientific presentation.
BM6055 **2** Independent Research Proposal	None
BM6070 **2** Biomicrofluidics ▷	Introduction to Micro Nano scale fluid flows and Mass transport - Navier Stokes equation, Convection Diffusion equation and analytical solutions for flows in rectangular channel cross sections - Flow field fractionation using Dielectrophoresis - Separaion and concentration of Cells on Chip using Acoustic, Magnetic and Optical fields - Microfabrication - materials - thin film deposition and patterning techniques - Bonding techniques - 3D/Multilayer fabrication of microfluidic Chips - Applications - Drug screening - SERS on Chip using magnetic nanoparticles - Single Cell trapping techniques on Chip - Stem Cell differentiation studies on Chip - Microfluidic PCR - Biochips for studies on Protein Folding.
BM6080 **2** Advanced Biomechanics ▷	Isotropic and Anisotropic models of elasticity - Nonlinear models for soft tissue mechanics - Biofluid mechanics - Newtonian and Non-Newtonian fluids -Effect of constituents of blood and synovial fluid on viscosity - Navier Stokes equation and analytical solutions for flows in different geometries - Non-Newtonian flow modeling - Arteial Blood flow - Pulsatile flows in arteries and analytical solutions for transient velocity field and shear stress - Oscillatory wall shear stress and its significance - modeling of Spherical Aneurysms
BM6090 **2** Biomedical Imaging	Medical imaging systems: Ultrasound, Photoacoustic imaging, MRI, X rays and CT, Nuclear imaging techniques: PET, SPECT, Optical imaging and microscopy, Molecular and Cellular imaging, Contrast agents (6 Lectures + Lab)
BM6100 **2** Bio-nanotechnology	The course will introduce Bio-nanotechnology from material's viewpoint. The course content will deal with various types of nanomaterials (zero dimentional, one dimentional, two dimentional and special nanomaterials) used in biology/medicine. The course will also introduce various characterization techniques in nanotechnology and the principles behind them. Students will be exposed to various applications of nanomaterials in medicine and biology through lectures and seminar discussions. • Introduction: About the course; Nanotechnology for biology and biomedical field (2) • Emergence of Bio-nanotechnology (2) • Bottom up and Top down approaches (2) • Challenges in Bio-nanotechnology (2) • Zero Dimentional Nanostructres (2)

- One Dimentional Nanostructures (2)
- Two Dimentional Nanostructures (2)
- Special Nanomaterials (2)
- Characterization and properties of Nanomaterials (2)
- Applications of Nanomaterials in biology (10)

BM6110 **2**
Nanomedicine

This is a highly interdisciplinary course for graduate students (M. Tech, Ph. D) who are interested in learning about the emerging field of nanoscience and nanotechnology and its application in biology and medicine. To capture the excitement of this emerging field, in this coruse student will be familiarized with fundamentals of nanoscience and Nano-scale engineering, and their potential application in the human health care system. This course will emphasize emerging nanotechnologies and its biomedical applications including fundamental of nanomaterials and nanoengineering, notoxicology, nanotechnology for drug delivery, regenerative medicine, imaging, and diagnostic system and translating nano-medicines into clinical investigation.

BM6120 **2**
Tissue Engineering

The students will learn how to test the biomaterials along with a number of cell types in vitro and in vivo. He should learn how the physiological cues are combined together with biomaterials for regenerative medicine point of view.
Syllabus: Tissue engineering: fundamentals and current status; Stem cells: embryonic and mesenchymal stem cells; cell differentiation; Extra-cellular matrix components and their regulation of cell behavior; In vitro and in vivo testing of biomaterials. Bioreactor; Cell migration; Growth factors; Different approaches for angiogenesis and its importance.

BM6140 **2**
Theoretical and Computational Neuroscience: From Cell to Systems

- Genesis of electrical activity in cells, resting membrane potentials
- Neuron equivalent circuits and passive propagation in neurons
- Hodgkin-Huxley equations and conductance based models
- Ion channels and their diversity
- Simple neuron models and analysis using dynamical systems concepts
- Chemical and electrical synapses and their models
- Neuronal networks and techniques for mathematical analysis
- Models of learning and memory in the neuron and the network
- Models of cognition, decision making and psychophysical models
- Systems (sensory and motor systems) and their modeling
- Neural coding (Rate, temporal, population)
- Neuronal data analysis techniques (Pre-processing, Spike detection and sorting techniques),

BM6150 **2**
Mathematical Physiology and Modeling

This course for senior undergraduates and postgraduates will introduce the principles of physiology and its mathematical characterisation. The course will cover the important elements of physiology like Cellular function, Growth, Homoeostasis and metab, Characterisation of some systems. E.g. Cardiovascular, Respiratory, Endocrine.

14.4 Department of Biotechnology

BO1010 **1**
Introduction to Life Sciences

Relevance of Biological Principles to Engineering undergraduates. Water and its special properties: Relevance to life. Building blocks of life: Bio-molecules and their structure-function aspects. Cell structure and organelles, cell membrane, cellular transport and signaling. How does a cell sustain life? Cell metabolism and its regulation; Cell energetic: harvesting chemical and solar energy. Cell division and cancer. DNA structure and packing. its replication, damage and repair: Consequences of unrepaired DNA damage. Dogma in Molecular Biology: Transfer of information from DNA to protein synthesis. Biotechnology.

BO5050 **1**
Gene Editing

Basic understanding of the cell and how it functions (role of gene to protein to function). Principles of gene expression and regulation and the idea of gene mutations and associated diseases. Fundamentals of DNA damage and repair process and their mechanisms. Introduction to gene editing strategy with regard to the principles of gene regulation and DNA repair process. Overview of gene editing techniques including, zinc finger nucleases (ZFNs), transcription activator-like effector nucleases (TALENs) and Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR)-Cas9. Application of gene editing tools with strong emphasis on Crisper-Cas9 system in understanding gene function, disease modeling, and therapeutic potential for genetic diseases including cancer and sickle cell anemia.

BO6015 **15**
Thesis-1

Independent research project leading to an M.Tech thesis. Students will learn to think creative, design and perform research projects independently under the guidance of a

faculty mentor.

BO6025 **0**
Thesis-2

Independent research project leading to an M.Tech thesis. Students will learn to think creative, design and perform research independently under the guidance of a faculty mentor.

BO6060 **0**
Protein Misfolding In Neurodegerative Diseases

Protein folding and misfolding, Amyloidogenicity, Molecular biology of protein misfolding in: Alzheimer's disease, Parkinson's disease, Huntington's disease, Amyotrophic Lateral Sclerosis (ALS), Creutzfeldt Jacob's disease (Prion disease), and non-neuropathic systemic amyloid diseases. Mechanism of amyloid toxicity. Prion formation, transmission and pathogenesis. Role of Chaperones and other cellular factors in modulating amyloid formation and toxicity. Role of mitochondrial damage in pathogenesis of neurodegenerative diseases. Eukaryotic yeast cell models of neurodegenerative diseases. Therapeutics of neurodegenerative diseases.

BO6063 **1**
Animal Models in Medical Research

The learning outcome of this course is knowledge about use of animal models in medical research. This course has a hands on module.
• Various animals as models and their advantages and disadvantages
• Animal research in medicine: modelling heart damage, autoimmune diseases, tuberculosis, Parkinson's
• Upcoming vertebrate animal model: zebrafish
• Practical session using animal model zebrafish

BO6083 **2**
Programming for Bio Macromolecular Data Analysis

This course is designed to provide knowledge about interdisciplinary approach in addressing biological problems.
Course Content: Linux commands: ls, vim, emacs, grep, sed, awk etc., shell scripting: if condition, while loop etc and their application in editing and organizing Protein Databank (PDB) files towards modeling and analysis of biomacromolecular structures and python scripting for Pymol software.

BO6113 **2**
Structural Bioinformatics

The overall aim of this course is to provide an outline of the structure of biomacromolecules that are major target for therapeutics and various algorithms used for biomolecular structure prediction.
Biomolecular Structure and Dynamics: Stereochemistry: configurational and conformational isomers - Internal parameters - Forces stabilizing biomolecular structure - Structure and dynamics of nucleic acids: base pair geometry, sugar puckering and phase angle of pseudo rotation, secondary structures of nucleic acids - Structure and dynamics of proteins: primary, secondary, tertiary and quaternary structures of proteins, Ramachandran diagram and conformation of proteins - Carbohydrate structure. Sequence alignment: Pair-wise alignment method, Dynamic programming: Needleman-Wunsch method; Smith Waterman method - Multiple sequence alignment method - Scoring function: BLASUM matrices - Heuristic method: BLAST. Structure prediction: RNA secondary structure prediction: Nussinov Algorithm - Protein secondary structure prediction - protein tertiary structure prediction.

BO6120 **2**
Advanced Immunology

The learning outcome of this course is detailed knowledge of advanced Immunology with recent advances in immunology including few clinical focuses.Quick overview of innate and adaptive immunity; Antigen and antibody: Structure and function; Antigen-antibody interactions as tools for research; Generation of antibody diversity: Immunoglobulin genes; Presentation of antigen by major histocompatibility complex molecules, Effector mechanisms; AIDS and the immune system; Vaccines. Special topics on advances in immunology.

BO6123 **2**
Cell Technology

This course is intended to provide practical handling experience of culturing of human cells.
Human cell culture media, growing cells, counting cells, cell cryopreservation, cell transformation with DNA, methods of DNA, RNA isolation from cultured cells; cell based assays with fluorescence microscopy; cell staining and cell survival analysis.

BO6133 **2**
Protein Technology

This course aims to provide knowledge of advances in protein research for industrial and biomedical applications to post graduate students.
Recombinant protein expression systems: E.coli, Yeast, Pichia, Insect-cells, cell-free protein expression. Protein purification techniques: Ion-exchange chromatography; Gel-filtration; Affinity chromatography; FPLC; HPLC. Proteomics: 2-D Gel Electrophoresis, Mass spectrometry, Protein microarrays. Protein characterization: Fluorescence Spectrometry; Circular Dichroism, Isothermal Titration Calorimetry. Mutant design and site-directed mutagenesis. Therapeutic proteins.

BO6143 **2**
Gene Technology

Gene technology course is designed to provide details of methods used in molecular biology, particularly PCR based cloning and mutagenesis for over expression of genes.

The course involves students independently performing the following in the class room: Retrieval of nucleotide and amino acid sequences of genes from NCBI database, components of cloning vectors, features of expression vectors, elements of prokaryotic and eukaryotic genes, analysis of restriction sites in genes and vectors, designing of primers for PCR amplification and directional cloning of genes, confirmation of insert sequence in ligated plasmid, primer design of achieving expression in multiple versions of expression vectors, requirement for generation of site directed mutants, creation of restriction sites for scoring of mutation, quantification of copies of mRNA or DNA fragments in clinical samples using qPCR.

BO6150 **2**
Molecular Basis of Cancer
▷Basic knowledge of Biology

This course aims to provide a detailed understanding of biological pathway leading to cancer and molecular understanding of anti-cancer therapy.

BO6160 **1**
Next Generation Sequencing Technologies and Application

Next-generation sequencing (NGS) technologies have revolutionized our understanding of complex diseases and allowed identification of newer targets for therapeutic intervention. The primary aim of the course is to cover the current and developing next generation sequencing technologies with emphasis on the scientific and medical applications of these technologies.
Introduction to next generation sequencing (NGS) technology, basic principles of NGS, introduction to various NGS platforms; their advantages and limitations, single-cell sequencing technology, basic and advanced biological applications of various sequencing technologies, clinical applications. The course will also provide an overview of the various tools available to analyze the sequencing data.
In addition, the course will also cover the recent scientific breakthroughs made using NGS technology.

BO6163 **1**
Modern Techniques In Neuroscience

This course is designed to introduce theoretical knowledge and some practical aspects of recent techniques in understanding neurobiology at molecular, cellular, circuit and behavioral levels.
Viral vector based neural circuit tracing, Optogenetics to control circuit activity and behavior, Calcium imaging by genetically encoded sensors (GCaMP, RCaMP), pH Sensitive Fluorescence reporter (pHluorin), Molecular Profiling by TRAP approach, Brainbow multicolor imaging, Functional MRI for brain imaging, Ex Vivo slice culturing, Primary Culturing in Neural and Glial Cells, Biochemical Techniques.

BO6180 **1**
Macromolecular Crystallography

This course is designed to give insights on macromolecules crystallization and resolving their structure by X-ray crystallography.
Art of macromolecules crystallization: The course deals with the rational approaches and methods in protein-protein and protein-nucleic acids crystallization.
X-ray Crystallography: Crystal symmetry and systems. X-ray diffraction, Structure factors and Phase problem in crystallography. Electron density equation and Phasing methods in crystallography. Model building and Refinement. Use of Ramachandran plots and other tools for structure validation. Graphics tools to visualize and analyze atomic structure of macromolecules. Case study for understanding biological phenomenon with structures.

BO6240 **2**
Structural Biology

The course emphasis on techniques used to determine and analyze the macromolecules organization and interactions. The course aims on case studies which enable students to use the information obtained from macromolecular structures and interactions studies for understanding a biological process. Quantification and characterization of interactions, involving proteins with other molecules termed as ligands (proteins, nucleic acids, carbohydrate, peptide, inorganic molecules etc), using appropriate biophysical techniques. Characterization of macromolecular assembly using principal techniques.
Principles of protein and nucleic acid structures: Three-dimensional conformations of proteins and nucleic acids. Covalent, non-Covalent and van der Waals interactions role in protein and nucleic acids structure and folding. Bioinformatics tools for analyzing motifs and folds. Protein and nucleic acids folding problem. Case study for understanding biological phenomenon with structures.

BO6250 **2**
RNA Biology and Therapeutics

The course aims to bridge fundamental aspects with the cutting-edge new discoveries in the field of RNA Biology. Due to ongoing rapid advances in the field, the course will integrate classroom teaching with discussions and will rely heavily on discussing scientific papers critically.
The course will cover metabolism and functions of RNA including synthesis, structure, processing, function and degradation of mRNAs, miRNAs, snoRNAs, rRNAs, tRNAs and long noncoding RNAs. A significant portion of the course will focus on the recent advances in RNA biology field including the role of RNAs in human diseases and RNA-based therapeutics. The course will also cover role of long noncoding RNAs and RNA modifications in regulating gene expression.

BO6290 **2**
Molecular Machines: DNA Interacting Proteins

In this advanced course, the students get to learn about aspects involved in interaction of a protein with DNA, such as, pathways for recognizing a specific sequence in genome, ways to access the nitrogen bases in the double helix, relation between binding and activity of the proteins, molecular mimicry, role of non-specific DNA, etc. The analysis and interpretation of current literature, followed by, design of experiments to probe activity of a protein on DNA form the core of the course.

BO6340 **2**
Epigenetics

This course is intended to provide the students with importance of epigenetics in modern biology. Histone modifications, chromatin structure and modifications; Overview of epigenetic mechanisms and their link to chromatin dynamics. Link between epigenetic mechanisms and DNA dependent activities. Structural and biochemical basis of covalent histone and DNA modifications reading, writing and erasing. RNAi: discovery, mechanisms, biological functions; Roles of micro-RNAs in gene regulation and embryonic development; epigenetic regulation of gene expression; variations in gene expression profiles during cellular differentiation.

BO6350 **1**
Membrane Biophysics

The course will focus on physical principles governing biological membranes, including lipid and transporter structures and dynamics as well as their mechanical characteristics and their effect in cellular transport.
Introduction to lipids and their structures, membrane protein motifs, molecular and ionic membrane transporters: passive and active, electrochemical gradient and diffusion, case studies of membrane protein transport mechanisms, role of transmembrane proteins in infectious diseases, modeling as a tool in studying membrane…transporter interaction dynamics.

BO6670 **2**
Stem Cell Biology And Regenerative Medicine

The course aims at providing students a solid foundation in stem cell biology and human diseases connected to stem cell biology. The course will also cover the stem cell therapies that are currently being used in clinics and discuss the future treatments that lie on the horizon. Due to the ongoing advances in the field, students will be expected to read and present seminal research literature on stem cell biology.

BO7053 **2**
Biomolecular NMR

Objective of the course is to provide the fundamental concepts of NMR and applications of NMR in understanding the biomolecular structure and dynamics.
Properties of electromagnetic radiation - Magnetic properties of nuclei - The nucleus in a magnetic field - Spin populations at thermal equilibrium and the NMR phenomenon - The classical vector model - Chemical shift - T1andT2 Relaxation - FID - A simple one-pulse experiment - Inversion-recovery method - J coupling - Polarization transfer - NOE - INEPT - The spectrophotometer - Introduction to product operator formalism - 2D NMR - 3D experiments and Sequential assignment strategies - Structure calculation protocol.

BO7280 **2**
Pharmacology and Physiology of Receptors
▷Basic knowledge of biology

- Receptor classification
- Fundamental principles of pharmacology: drug receptor interactions.
- Techniques used to study receptor localization, trafficking and signaling.
- Principles of cardiovascular pharmacology.
- Voltage gated ion channels: assay technologies available,
- Channelopathies.

BO7390 **2**
Cellular and Molecular Neuroscience

Basic understanding of the nervous system development and function. To understand generation and architectural organization of brain cells. Basic cell biology, biochemistry and molecular biology of neuron, how neurons are electrically excitable, role of ion channels, surface receptors and synapse formation and synapse plasticity. Principles of neural circuit formation and function and ways to manipulate them. Introduction to nonneuronal cells (glial cells- astrocytes, oligodendrocytes and microglia) of the brain and their emerging role in controlling neuronal function. Overview of innovative experimental tools including optogenetics and CLARITY in uncovering neural circuit assembly at cell and molecule level. Concept of neurodevelopmental and neurodegenerative diseases and possibility of development of new tools to better understand disease mechanism.

14.5 Department of Civil Engineering

CE2020 **1.5**
Construction Materials

Structure and properties of materials, Production of ferrous metals and characteristics; Types of major rolled steel shapes; Properties of Structural Steel, Cold-formed steel and its properties; steel and aluminium, masonry and mortar, polymers and plastics, Composites and wood.

CE2021 Construction Materials Lab	**2**	Physical tests on cement, fine and coarse aggregate; tests for workability; tests on hardened concrete; compression tests on cubes and cylinders; modulus of rupture test on concrete beams; rebound hammer and UPV test on hardened concrete; Testing of bricks for efflorescence, water absorption and compressive strength; Tension Tests on Steel/ Wood/Composite Coupons.
CE2030 Concrete Technology	**1.5**	Manufacture and chemical composition of cement; Hydration of cement and products of hydration; Influence of temperature and water to cement ratio on hydration of cement; Admixtures for improving properties of fresh and hardened concrete; properties of aggregate; concrete mix design; Properties of fresh and hardened concrete; durability and long-term performance of concrete; special concretes and self-consolidating concrete.
CE2031 Fluid Mechanics Lab	**1**	Flow in open channel. Fluid friction. Hydro-statistics and properties of fluids. Impact of jets. Notches. Pressure measurements. Flow measurement.
CE2100 Introduction To Structural Analysis	**1.5**	Types of Structures and Supports; Free - Body Diagram; Forces and Moments; Analysis of Various statically - determinate structures; Cables, Arches, Beams; Influence Lines and Energy Methods.
CE2101 Structural Mechanics Lab	**2**	Flexural Stresses and Deflection in a Simply Supported Steel Beam; Symmetrical and Unsymmetrical Bending of Steel Sections; Compression Test on Composite Column; Tension Test on Steel Sections, Column Buckling Test, Indeterminate Beam testing, Torsion testing, Pin jointed frame work analysis, Three and Two hinged Arches.
CE2110 Analysis Of Indeterminate Structures	**1.5**	Introduction to Statically Indeterminate Structures; Flexibility for Analysing Statically Indeterminate Structures. Slope deflection method, Moment distribution method, Force method, Stiffness method for truss, beams and frames.
CE2500 Engineering Hydrology	**2**	Measurement, analysis, and interpretation of various components of hydrologic system (precipitation, infiltration, runoff, evapotranspiration); Rainfall - Runoff correlations; Hydrograph analysis; Groundwater hydrology and wellhydraulics.
CE3010 Fundamentals Of GIS And Remote Sensing	**2**	Principles of electromagnetic radiation; Data analysis and image interpretation; Coordinate system and map projections; Spatial data management; Map overlay and geo processing; Spatial, geo-statistical, Network tools in GIS; Introduction to model building with GIS.
CE3011 GIS Lab	**1**	Working with ERDAS -> Data interpretation and geo referencing; Image classification; Image interpretation techniques Working with ArcGIS -> Spatial joins and geo processing; Editing and geocoding algorithms; Vector and Raster analysis; GIS networking
CE3020 Surveying	**2**	Geo-informatics, Principles of surveying, Errors in measurements, Maps, Linear Measurements, Measurement of Directions, Bearings and angles; Compass surveying- magnetic bearings, declination, local attraction errors and adjustments; Theodolites, Traversing, Triangulation and Trilateration, Purpose and classification of each; Compass and theologize traverses, Triangulation, Adjustment Computations.
CE3102 Introduction To Reinforced Concrete	**1.5**	Mechanical properties of reinforced concrete materials including shrinkage, and creep; Load displacement behavior under pure compression and pure tension; Basic Bending Theory; Moment-curvature and load-deflection relationships; Shear Behavior of RC Members; Torsional Behavior of RC Members.
CE3122 Reinforced Concrete Design	**1.5**	Probabilistic load theory; Design Philosophies; Difference between strength and limit state design; Introduction to cods of design – IS 456 and IS 875; Design for Flexure and Shear; Design of Columns subjected to axial load and uniaxial bending; Introduction to Design of slabs; Introduction to Design one-way and isolated footings.
CE3132 Design Of Steel Structures	**1.5**	Types of Beam Buckling Failures; Design of beams and beam-columns, Connections - Bolted Connections Welding and Welded Connections -Bolt Group, Weld Group; Beam and Column Splices.
CE3142 Introduction To Structural Steel Design	**1.5**	Mechanical Properties of Steel; Effect of Corrosion; Fire and Fatigue; Limit State Design - Analysis procedures and Design Philosophy; Design of Tension Members; Compression Members - Elastic Buckling, Strength Curves, Strength of Compression Members, Concept of Effective Lengths, Types of Column Sections, Design of Axially Loaded Columns.
CE3300 Geotechnical Engineering - I	**1.5**	Introduction to Geotechnical engineering, Rock cycle, Clay Mineralogy, Phase Relationships, Grain-Size analysis, Plasticity and Soil Classification, Compaction,

		Standard/Modified Proctor Test, Field Compaction, Permeability, Seepage.
CE3301 Geotechnical Engineering Lab	**2**	Visual Soil Classification and Water Content, Sieve Analysis, Liquid Limit and Plastic Limit, Hydrometer Analysis, Standard Proctor Test, Field Density Test, Constant and Variable Head Permeability Test, Oedometer Test, Unconfined Compression Test, Direct Shear Test, Unconsolidated and Undrained Test.
CE3310 Geotechnical Engineering - II	**1.5**	Effective Stress Principle, In situ Stresses, Mohr's Circle, Vertical Stresses, Boussinesq's and Westergaard's Theories, Terzaghi 1D Consolidation Theory, Compressibility, Secondary Consolidation, Settlement Calculations, Shear Strength, Direct Shear and Triaxial Shear Tests, Drained and Undrained behavior of sands and Clays.
CE3312 Introduction To Foundation Engineering	**1**	Foundation Design - Limit State and Working Stress, Tolerable Foundation Movements, Site Investigations, In-Situ Testing (SPT and CPT) and their Interpretation, Field vane Shear Test, Foundation Types and their Installation (Shallow and Deep), Shallow Foundation Settlement.
CE3322 Design Of Foundations	**2**	Limit Bearing Capacity and Design of Shallow Foundations, Analysis and Design of Axially and laterally Loaded single piles, Under-reamed Piles, Pile Groups; Retaining Walls, Earth Pressure Theories and Design, Reinforced Earth Structures, Slopes, Limit Equilibrium Methods- Method of Slices, Sheet Pile Wall and Braced Excavations.
CE3500 Introduction To Hydraulic Engineering	**1.5**	Analysis and design of water distribution system; Steady and Unsteady flows in closed conduits; Design principles of hydraulic structures; Introduction to Hydraulic Machinery.
CE3501 Hydraulic Engineering Lab	**1**	Impact of jet on fixed vanes; Developing characteristic curves for axial / radial flow turbines, and centrifugal pumps; Experimental investigation of sediment movement in open channels; Analysis of flows in fixed bed and tilting channels.
CE3510 Open Channel Hydraulics	**1.5**	Application of energy and momentum principles in open channels; Uniform flow; Concept of specific energy; Gradually varied flow analysis; Rapidly varied flow; Hydraulic jump analysis.
CE3511 Environmental Engineering Lab	**2**	Determination of physical contaminants: solids, turbidity, pH, electrical conductivity, Jar test; acidity and alkalinity of water; hardness of water; dissolved oxygen content of water; chemical oxygen demand; biochemical oxygen demand; chlorine and bleaching, MPN Test, demonstration of advanced equipment.
CE3512 Introduction To Environmental Engineering	**1**	Concept of environmental pollution: air pollution, water pollution, solid waste, special waste; sources, measurement techniques and criteria; fate and transport of contaminants; treatment technologies; key concepts, examples and case studies will be presented. Important lab instruments will be introduced, along with field visit.
CE3522 Water And Waste Water Engineering	**2**	Chemical and biological concepts, reactions, material balance, flow models and reactors, water quality, wastewater characteristics. Screening and shredding, grit removal, flow equalization, coagulation, flocculation, sedimentation, filtration, disinfection. Aerobic suspended growth processes, aerobic attached growth processes, anaerobic processes. Sludge processing and land application of biosolids.
CE3530 Air Pollution	**2**	Introduction, atmosphere and its characteristics, sources and effects of air pollution, meteorological aspects of air pollutant dispersion, air pollution sampling and measurement, air pollution control methods and equipment, control of particulate and gaseous pollutants, atmospheric chemistry - stratospheric chemistry, chemistry of ground-level air pollution, indoor air pollution, Air (Prevention and Control of pollution) Act.
CE3820 Highway Design And Materials	**2**	History of highway development, Surveys and classification of roads, Highway elements, Geometric design of highway, Advanced highway geometric design, Pavement materials and testing; Material characterization for design; Design of highway; Highway construction, maintenance and rehabilitation.
CE3821 Highway Materials Lab	**1**	Laboratory testing of road aggregates, bituminous binders and mixes for their suitability in road construction with reference to IRC/BIS specifications. Sub grade evaluation - California bearing ratio, resilient modulus, modulus of sub grade reaction; Pavement evaluation studies -measurement of pavement distresses, deflection studies.
CE3830 Railway And Airport Engineering	**1**	Railway Engineering: Railway location surveys and alignment, Permanent way, Gauges, Functions and requirements, Geometric design, Track Junctions, Points and crossings, design and layout, Railway stations and yards. Railway track drainage Airport Engineering: Aircraft characteristics, Airport obstructions and zoning, Runway,

taxiways and aprons, Terminal area planning, Airport site selection; Geometric design of railway and airfield elements.

CE3840 **2**
Traffic Engineering And Planning

Traffic Engineering: Traffic stream components and characteristics; Theories of traffic flow; Traffic studies; Design of control strategies for simple systems like intersections, roundabouts, freeways, etc.; Capacity and level of services of various transportation facilities. Multilane highways capacity and LOS, Introduction to Intelligent Transportation Systems.
Transportation Planning: Introduction to urban and regional transportation planning; Urban transportation planning process; Activity based travel demand modeling.

CE3841 **1.5**
Traffic Engineering Lab

Traffic studies, Volume studies, Speed studies, Intersection studies, Gap acceptance studies, Parking studies, Origin-destination studies.

CE4330 **1**
Geology I

The Earth: surface and internal structure; thermal gradient, earthquakes, isostacy, ocean ridges, magnetism, continental drift and age. Geological history, Weathering processes; rock forming minerals; igneous, sedimentary and metamorphic rocks. Faults, folds and unconformities, Engineering properties of rocks; Law of superposition.

CE4500 **2**
Water Resources Engineering

Reservoir planning and operation; Seepage theories; Design of gravity dams; Analysis of earthdams, Spillways and energy dissipaters; Soil-crop-water relations; Methods and types of irrigation; Crop water requirement.

CE4510 **2**
Environmental Impact Assessment

Introduction to Environmental Impact Assessment (EIA), need, limitations, stages and types of EIAs, matrices, cost-benefit analysis, assessment of impact on land, water, air, people and culture, flora and fauna, case studies.

CE4900 **2**
Construction Management

Objectives, Construction planning, scheduling procedures and techniques, Cost control, monitoring and accounting, The cost control problem, The project budget, Financial, Accounting systems and cost accounts, Control of project cash flows, Schedule control, Quality control and safety during construction.

14.6 Department of Chemical Engineering

CH1010 **2**
Material and Energy Balances

Review of basic concepts: units and dimension, material properties, process variables and stoichiometry; Techniques for problem solving; Steady state material balances for processes involving no reaction; Steady state material balances for processes involving reaction: species and elemental balances, combustion of fuels; Recycle, bypass and purge calculations; Steady state material balances involving multiple units; Steady state material balances in multiphase systems ; Steady state energy balances for processes with and without reaction; De-Coupled and coupled mass and energy balances; Degree of freedom analysis; Unsteady state material and energy balances.

CH1020 **2**
Introduction to Thermodynamics

Basics of Thermodynamics: Laws, Allied postulates, Different terms and related aspects; Equations and Relations; Single Component Phase changes and related phenomenon; Basic Definitions; Thermodynamic Cycle (Carnot, Rankine, Refrigeration, Auto and Diesel Cycles etc); Definition of non-equilibrium; Need of Statistical Mechanics.

CH1021 **1**
Chemical Engineering Lab

A laboratory course designed to introduce the wider aspects of Chemical Engineering (a multi-scale approach) in today's perspectives. It includes experiments related to basic chemical engineering thermodynamics, process control to state-of the-art topics such as surface and interfacial sciences to advanced materials.
Objective of this laboratory course is to spark the young students with multi-directional facets of Chemical Engineering right in the beginning.

CH1030 **2**
Fluid Mechanics

Scope and Applications, Definition of Fluid, Concept of Continuum, Dimensions and Units. Fluid Properties: Velocity and Stress field, Density, Viscosity, Surface Tension, Pressure, Temperature. Fluid Statics: Basic equations, Pressure variation in static fluid, Manometers and Hydraulics, Fluid force on plane/curved submerged surface, Buoyancy and Stability. Fluid Dynamics: 1D, 2D, and 3D Flows; Timelines, Pathlines, Streamlines; Streaklines; Viscous and Inviscid Flows, Laminar and Turbulent flows, Compressible and Incompressible flows, Internal and External flows. Basic equations in Integral form/Differential form: Mass conservation, Momentum conservation, Energy conservation, Angular momentum principle. Incompressible Inviscid flow: Euler's equation, Bernoulli's equation, Irrotational flow. Dimensional Analysis; Similitude. Internal Incompressible Viscous flow: Fully developed laminar flow in channel; pipe,

flow measurement devices.

CH1040 2
Chemical Reaction Engineering - I

Elementary/non-elementary reaction; reaction order, molecularity, Mathematical modeling of reaction mechanism, polymerization/biochemical reaction, Rate data analysis, Variable volume reaction system. Isothermal reactor design: Batch, Mixed and Plug flow reactors, multiple reactor system, multiple reaction system, series/parallel/complex reaction, reaction network, Residence time distribution (RTD); RTD in ideal reactors; Reactor modeling using RTD: Segregation model, maximum mixedness model; RTD and multiple reaction.

CH1050 1
Introduction to Mass Transfer

Definition of Mass Transfer, Examples; Classes of Mass Transfer operations; Methods of Mass Transfer Operation; Principles of equipment design; Basics: Diffusion, Mass Transfer Coefficients.

CH1060 2
Heat Transfer

Conduction: Fourier Law; Steady state conduction in 1D; Critical and optimal thickness of insulation; Steady state conduction in multiple dimensions; Numerical heat conduction; Convection: Energy equation on boundary layer; Thermal boundary layer; Reynolds's and Colburn analogy; Free convection; Radiation: View factors; square of the distance effect; radiation between black surfaces; infinite parallel planes; radiosity, irradiation and surface resistance.

CH1080 2
Separations Process - I

Theory of Interphase Mass Transfer (Equilibrium between phases, Henry's Law, Raoult's Law; Gas and Liquid Phase resistances); Absorption Operations and Equipment used (Concepts of Operating and equilibrium lines, co-current, counter-current flows, different methods of calculating stages, application, Tray design concept, Design parameters, Design for Packed Towers); Overview of Distillation (Thermodynamics of Distillation, Basic Operation and Basics of Design Parameters)

CH1480 1
Chemical Technology

Introduction to chemical technology; Overview of various chemical process industries including petroleum refinery, petrochemical industries, inorganic chemical industries (chlor-alkali industries, mineral acids, and ammonia), fertilizers industries, pulp, paper, and rayon industries, and soap and detergents industries.

CH2010 2
Mechanical Operations

Characterization of particulate solids; Solids handling and storage; Comminution theory and Equipments; Principles of mechanical separations involved in the fluid- particulate solid systems, flow through porous media (packed beds), fluidization, gravity settling operations, centrifugal separations, gas - solid separation processes, filtration theory and equipment, separations involved in froth flotation, electrostatic and magnetic separation.

CH2011 1
Applied Chemistry Lab

Determination of Total Organic Carbon from Wastewater sample; Measurement of Surface/Interfacial Tension of Liquid-Liquid system; Measurement of pH and conductivity of Polymer Solution; Preparation and Characterization of Langmuir Blodgett Thin films; Determination of Flash and Fire Point of Fuel; Determination of Water hardness; Measurement of Contact Angle of Solid samples; Determination of Calorific value of fuel; Proximate analysis of coal; Measurement of Viscosity of Polymer Solution; Determination of Cloud and Pour Point of Lubricant; Determination of melting and boiling point of polymers.

CH2020 1
Basic Control Theory

First order systems; response of first order systems to different forcing functions. Second order systems. Underdamped, critically damped and overdamped systems. Servo and regulator problem. Block diagrams. PD, PI, and PID controllers.

CH2021 1
Mechanical Operations Lab

Estimation of Power draw/Work-index of mineral rock in the Ball Mill and Rod Mill; Measuring the size reduction ratio and power draw for Jaw crusher using Comminution laws; Determining the filter medium and cake resistance of plate and frame filter press; Particle classification through a hydrocyclone; Identifying the settling zone and estimation of particle hindered settling velocity in sedimentation; Fine Coal/Mineral separation using Froth Flotation

CH2030 2
Numerical Methods - I

Review of computer programming; simultaneous linear algebraic equations, Gauss elimination, partial pivoting, LU decomposition, matrix inverse, Gauss-Seidel method, relaxation, Eigen value calculations, roots of nonlinear equations, successive substitution, Newton's method, single variable / multiple variable methods, functional approximation, curve-fitting, linear and nonlinear regression, Newton's forward and backward difference interpolation, Lagrangian interpolation, Pade and cubic spline approximations, numerical differentiation and integration.

CH2040 2
Heat Transfer Equipment and Design
▷Heat Transfer

Boiling and condensation; heat exchangers: types and classification; logarithmic mean temperature difference (LMTD); overall heat transfer coefficients from individual heat transfer coefficients; heat transfer coefficient in shell and tube exchangers; LMTD correction; effectiveness and number of transfer units (NTU); Evaporators: single effect

and multiple effect; methods of feeding; enthalpy balance. Process design of shell and tube and double pipe heat exchangers; Process design of single effect and multiple effect evaporators.

CH2060 **1**
Numerical Methods - II

Ordinary differential equations, First-order ODEs, explicit Adam Bashforth methods, implicit Adam Moulton methods, multi-step methods, predictor-corrector methods, Runge-Kutta methods; step size controls, estimation of errors, stability of algorithms, stiff ODEs; system of first-order ODEs; higher-order ODEs.

CH2080 **2**
Chemical Reaction Engineering - II

Models for non-ideal reactors: tank-in- series model, dispersion model; modeling of real reactors with combinations of ideal reactors; stoichiometric table, reaction network analysis, effect of pressure drop on performance of plug flow vessels. Steady state non-isothermal reactor design,energy balance on batch, plug flow and CSTR reactors, optimal design for exothermic reversible reactions, stability and multiplicity of steady states in CSTR; unsteady state non isothermal reactor design: unsteady state energy balance, unsteady operation of batch, plug flow and CSTR.

CH2100 **1**
Heterogeneous Reaction Engineering

Adsorption kinetics, kinetics of catalytic reaction, External diffusion effects on heterogeneous reactions, reaction and diffusion in porous catalysts, catalyst deactivation, design for deactivating catalysts, Kinetics and reactor design of fluid-fluid and Fluid-particle system , Design of heterogeneous catalytic reactor: fixed bed reactor, slurry reactor, trickle bed reactor and fluidized bed reactor.

CH2120 **1**
Fluid Mechanics Lab

Fluid Mechanics: Measurement of fluid properties; Pressure measurement using U-tube and inclined manometers; Measurement of discharge using notches; Impact of water jet; Flow measurement using venturimeter, orifice meter, rotameter; Measurement of friction losses.

CH2580 **2**
Petrochemical Industry

Motivation and Socio-Economic Spread, Definition and Categories of Petrochemicals, Petrochemical Production: Steam Cracking, Fluid Catalytic Cracking, C4- C5- Stream Processing, Production and Product Profiles for Syngas/ Olefins / Aromatics, Product Profile of lesser known Petrochemicals.

CH3010 **2**
Separation Process II

Flash distillation, Column Distillation: (Binary),Column Distillation (Multi-component); Liquid-liquid extraction principles; Solid liquid extraction, phase rule and phase diagram, tie lines, co-current and counter-current operation; Leaching; Adsorption; Introduction to chromatography, crystallization principles; Drying; Humidification.

CH3011 **1**
HT Lab

Heat Transfer experiments: Temperature measurement and calibration; Measurement of thermal conductivity of solids; Unsteady heat transfer in solids; 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; heat transfer coefficient in vertical condenser and horizontal condenser.

CH3020 **1**
Transport Phenomena - II

Dimensional analysis of the equations of change; Momentum Transport - Time dependent flows: method of similarity solutions, Sturm-Liouville problems; Two-dimensional flows: stream function, limiting cases: creeping flow, inviscid flow, potential flow, velocity potential; boundary layer theory; Turbulent flow, transition to turbulence, turbulence models. Energy Transport - Forced and free convection: Boussinesq equation of motion; temperature distributions with more than one independent variable: unsteady heat conduction, steady heat conduction in laminar flow; boundary layer theory for nonisothermal flows. Mass Transport - equations of change for multicomponent systems; concentration distributions with more than one independent variable.

CH3021 **1**
Reaction Engineering Lab

Chemical reaction engineering: Selected laboratory experiments based on performance of batch, plug flow, continuous stirred tank reactors (CSTR), adiabatic reactor, packed bed reactor, residence time distribution (RTD), polymerization reaction, biochemical reaction and kinetics of homogeneous and heterogeneous reaction.

CH3022 **1**
Mass Transfer Equipment Design

Review of Vapor Liquid Equilibrium: Chemical Potential, Gibbs Phase Rule, Fugacity, Activity Coefficients, Predicting VLE equilibrium constants and Henry's Law. Design of flash distillation units: Binary and Multicomponent Distillation, Calculating flow rates, compositions and energy requirements, Rachford-Rice equation, sequential and simultaneous solution methods. Design of distillation columns: Binary Distillation, Dynamic mass and energy balances, Tray hydraulics, Empirical correlations for column pressure drop, efficiency calculations, estimating flooding and weeping, Column sizing, Dynamic control configurations and methods, Control using RGA, Multicomponent Distillation, Alternating convergence method for solution, Multistage Batch Distillation. Design of absorption columns: Equilibrium curve, operating line, number of ideal stages, Efficiency (Murphree and tray efficiency), design analysis for dilute and concentrated systems, Kremser equation, Packed tower: Mass transfer coefficients, height and number

	of transfer Unit (HTU-NTU). COCO simulator will be used in hands-on sessions for automatic solution of flowsheets with a combination of these unit operations.
CH3030 2 Transport Phenomena - I	Vectors and tensor algebra and calculus. Momentum transport - Viscosity, stress tensor, mechanisms of momentum transport; shell momentum balances, boundary conditions; governing equations: equations of continuity and motion, applications to steady, unidirectional flows; Energy transport - Thermal conductivity, mechanisms of energy transport; shell energy balances; equations of change for nonisothermal systems; Mass transport - Diffusivity, mechanisms of mass transport; shell mass balances, concentration distributions in laminar flow. Analogy between the three transport phenomena.
CH3031 1 MT Lab	Mass Transfer experiments: Basic Mass transfer experiments with simple calculations: Packed-bed Absorption, Packed-bed Extraction, Distillation (batch and continuous), Adsorption, Vapor-liquid equilibrium.
CH3041 1 Process Control Lab	Control Valve Trainer: Understand various types of control valves, Quick opening, Linear, Equal Percentage by changing the pressure signal to the valves and measuring the flow using the provided rotameter; Pressure Control System: Perform open loop step testing and obtain a model relating pump- speed, opening of a solenoid valve and pressure. Implement PID control of the pressure in the process vessel using pump- speed and the solenoid valve; Four- Tank System: Perform open loop step testing and obtain a model relating liquid level in each of the tanks to the flow rates. Implement level control in various configurations; Heat Exchanger: To perform open loop testing and obtain a model relating hot, cold water flows and the temperature. Implement PID control of temperature using the hot and cold water flow rates. Heater Board: Developing a first order model and Implementing temperature control of the plate by regulating the power to the heater. Distillation Column: Obtaining continuous steady state in a Distillation column, Perform step tests in reboiler power, reflux ratio, feed pump power (feed flow rate) and developing a lower order model.
CH3042 2 Plant Design - I	Process Synthesis, Materials and Energy Balance, Computer Aided Design, Flow-sheet Development, Aspects of Instrumentation-Control-Storage-Materials.
CH3050 2 Control Design and Analysis	Modelling of Dynamic Processes, Linear Time Invariant (LTI) systems, Stability of Linear and Non-Linear systems, Dynamics of sensing elements, Frequency Response of LTI systems, Bode stability criterion, Gain and Phase Margins, Nyquist plot, Cauchy's Principle, Nyquist stability, Root Locus (Asymptotes, Break-Away points), Review of P, PI, PID controllers, Cohen-Coon Method, Ziegler Nichols Method, Smith Predictor, Feed-forward control, Cascade control, Multi-Input Multi-Ouput (MIMO) systems, Loop interactions, Controller Design using Relative Gain Array (RGA), Model Predictive Control (MPC), Demonstration of MPC for Distillation Column control. Additional topics that may be covered : Inverse Response, Pole Placement, Sensitivity Functions, Internal Stability, Robust Stability Theorem, Fundamental Limitations on Feedback Control structure, Effect of NMP/ LHP zeros on control Design, Sensitivity Bounds.
CH3070 2 Chemical Engineering Thermodynamics - I	Recap for Thermodynamics of Laws, Allied postulates, Different definitions and related aspects, Entropy Balance, Single Phase, Pure Fluid Industrial Applications, Behavior of Mixtures, Liquid Models, Vapor-Liquid and Liquid-Liquid Equilibria Chemical Equilibria.
CH3090 1 Chemical Engineering Thermodynamics - II	High-pressure phase equilibrium, Osmotic equilibrium, Introduction to Electrochemical Thermodynamics, Partition of solute among two solvents, Advanced Liquid Models, Introduction to Intermolecular forces, Introduction to Statistical Mechanics.
CH3580 1 Introduction to Nanotechnology	Evolutionary perspective of Nanomaterials, Physical aspects of Nanosciences, Synthesis, Design and Characterization of Nanomaterials, Nanofabrication methods and Product form of Nanomaterials.
CH4011 2 Process Simulation Lab	Usage of programming environment e.g. MATLAB to solve engineering problems that are expressed by ordinary differential equations boundary value problems (ODEBVP) and Partial differential equations (PDEs) - Usage of MATLAB to solve engineering optimization problems.
CH4012 1 Plant Design - II	Role of Safety in Design, Economic Analysis and Feasibility, Depreciation Methods, Economic evaluation (NPV, DCFROR etc.), case studies relating process, equipment, plant design, from concepts to product (concept, lab scale, prototype/ pilot scale, further scale-up)

CH4020 **2**
Optimization

Concepts of optimization, formulation of optimization problems, unconstrained optimization, necessary and sufficient conditions, convexity, single and multi-variable optimization, constrained optimization, KKT conditions, numerical optimization, one dimensional area elimination and interpolation based methods, multi dimensional Newton's / Quasi - newton methods, evolutionary optimization, genetic algorithms, solving practical problems.

CH4450 **1**
Biomechanics

Biomechanics in human health, cellular basis for biomechanics, Basics of Continuum Mechanics (Equilibrium, Stress, Strain, Constitutive models), Example problems in Biosolid Mechanics (Extension and Torsion of bone)

CH5050 **2**
Non-isothermal Reactors

Overview of reaction engineering and emerging challenges, stoichiometric table, reaction network analysis, effect of pressure drop on performance of plug flow vessels, energy balance and non-isothermal reactors design, optimal design for exothermic reversible reactions, stability and multiplicity of steady states in CSTR.

CH5091 **2**
Simulations Lab - 1

Simulation concepts, Aspen Plus - Introduction, Reactor models, Distillation models, Process simulation - Steady State and Dynamic, Process Control, Economic Analysis. Introduction to molecular dynamics (MD) and monte carlo (MC) simulations.

CH5180 **2**
Viscous Fluid Flow

Properties of Fluids, Fundamental equations of fluid flow: Derivation of Navier-Stokes, continuity and energy equations, Boundary conditions for viscous flow, Some discussion on potential flows: stream function, potential function, Flow separation, Dimensionless parameters, Laminar boundary layers, similarity solutions: Blasius velocity profile for flow over a flat plate, Transition to turbulence: linear stability analysis, Introduction to Turbulence

CH6020 **1**
Sustainable and Energy Options

It covers basics of renewable/nonrenewable and sustainable energy, global consumption of energies; includes different types of energy utilization. Advance of sustainable energy towards fossils; conventional energy resources; inexhaustible and environmental application.

CH6040 **1**
Process Intensification

History of Chemical engineering: evolution of chemical processes and process equipment; Process intensification: a paradigm shift in design, role of disruptive innovation; Process integration: heat and mass integration, reactive separations; Processing under centrifugal fields– HIGEE, spinning disk reactors, POD; Alternatives to stirred-tank mixers and reactors –Oscillatory baffle, Couette flow, 'custom-shaped' channel (Corning) mixers and reactors; Monolith (Structured) reactors and adsorbers; Micro devices: mixers, separators, heat exchangers, reactors for desk-top manufacture in Pharmaceuticals and fine chemicals.

CH6120 **1**
Fluidization Technology

Fundamentals of gas-solids fluidization, Application of fluidization-based processes in the industry, Regimes of fluidization, Geldart classification of solids, Minimum fluidization velocity, Bubbling fluidization, Hydrodynamics of the fluidized bed, Pressure profile along the fluidized bed reactor, Solids inventory, Circulating fluidized bed (CFB) reactors, Fluidized reactor designs, Comparison of BFB, CFB and ICFB systems, Heat and mass transfer processes in fluidized beds, Overview of modern fluidized bed-based industrial processes.

CH6140 **2**
Petroleum Refinery

Evaluation and characterization of crude oil: TBP and other distillation tests. Petroleum products, their properties, specification and testing different properties like flash point, fire point, smoke point, aniline point, carbon residue, kinematic viscosity, pour point, freezing point etc. Petroleum refinery distillation-pre- fractionation and atmospheric distillation of crude. Stabilization of naphtha. Vacuum distillation of RCO. Reforming of naphtha. Other secondary processes like Vis-breaking, FCC unit. Hydrotreatment processes in refining: hydro-desulfurisation, hydrofinishing, Hydrocracking. Production of lube oil base stock.

CH6160 **1**
Introduction to Biological Engineering

This course introduces the field of biological engineering, where the principles of engineering are used to solve problems in medicine and biology. Topics covered include an introduction to biological systems, application of industrial fermentation, microbial metabolism and biochemistry approach to understand the cloning, genetically modified products, bio-molecules, vitamins and enzymes. Studies on bioreactors systems on upstream, production and downstream, operation, control towards engineering approach to biological systems.

CH6170 **1**
Interfacial Chemistry

Introduction to Colloids and Interfaces; Forces in Colloidal Systems; Stability of Colloids; Surface Forces, Adhesion and Wettability

CH6220 **2**

Characterization of particles in liquids; Particle sizing techniques; Particle drag and

Advanced Soild-liquid Separations		settling rates; Rheology of slurries; Efficiency indices of separation of particles; Coagulation and flocculation; Gravity clarification and thickening; Classification by cyclones; Gravity separations; Separation by centrifugal methods; Filtration-fundamentals, cake washing, cake growth concepts; Pressure filtration; Vacuum filtration; Membrane separations; Latest developments of Solid-liquid flows.
CH6250	**1**	Properties of water; Synthesis and properties of Lubricants; Fuels; Polymers; Explosives; Cement; Adhesives; Nanomaterials.
Engineering Materials		
CH6310	**3**	Mechanics and Human Health, Preliminaries, Anatomy and Physiology of Cardiovascular system, Preliminaries of Continuum Mechanics, Problems and solutions in cardiovascular mechanics
Cardiovascular Mechanics		
CH6330	**1**	Mathematical representation of biochemical system in time and space, Simulation of spatio-temporal dynamics of intra-cellular molecules and physiological activities (MATLAB), Examples from cell growth, cell death, bacterial infection and cell migration, Biological signals and systems, Overview of system properties, Ultrasensitivity, Amplification, Oscillations, Network model formulation and motifs, Introduction to disease models.
Systems Biology		
CH6400	**1**	Overview of petroleum refinery and petrochemicals, Scenario of energy and chemicals and need for renewable feedstock; introduction and overview of bio-refinery, fuels and chemicals from vegetable oils; bio-alcohol as feedstock for fuels and chemicals; synthesis gas from biomass, overview of gasification, pyrolysis, and reforming; fuels and chemicals from synthesis gas; fuels and chemicals from biomass.
Biorefinery		
CH6420	**2**	Definition of non-Newtonian behavior, Examples with underlying mechanisms, Flow problems and solutions for i) Single-phase non-Newtonian models, ii) Multi-phase non-Newtonian models (mixture theory and correlation-based), and iii) Particulate suspensions
Non-newtonian Fluid Mechanics		
CH6450	**1**	Linear Time Invariant systems, Sampling, Transfer Functions, Frequency Response, Periodograms, Signal Spectra, Basic Probability review: Random Variables, Expectation, Variance, Covariance, Independence, Conditional Expectation, Quasi stationary signals, Spectra for random signals Prediction, one-step ahead Prediction, Observers Models for LTI systems: Equation Error, ARMAX, Output Error, Box Jenkins, General Family of Model Structures, Linear Regression Nonparametric methods : Correlation Analysis, Frequency Response Analysis, ETFE, Spectral Analysis Introduction to Prediction Error Methods Basics of Compressive Sensing and Model Validation.
Introduction to System Identification		
CH6460	**2**	Fundamentals of bioprocess engineering, Kinetics for growth and enzyme analysis. Process optimization through statistical techniques 2K, CCD, BBD, upstream development, fermentation and downstream technology by purification of biomolecules, large scale production of enzymes and byproducts. Solid state fermentation and Sub-merged fermentation process.
Bio-process Technology		
CH6470	**2**	Bias, Consistency of parameter estimates, Convergence of Random Variables, Analysis of the Least Squares Estimate, Best Linear Unbiased Estimate, Maximum Likelihood Estimator, Cramer-Rao Lower Bound Properties and Smoothing of ETFE, Weighting Functions Model Structures, Identifiability, Input Signals, Persistent Excitation, PRBS, Optimal Prediction, State Space Models, Kalman Filter, Theoretical Properties of Prediction Error Methods : Asymptotic distribution of parameter estimates, Instrumental Variable Methods and Analysis of Estimates, Recursive Identification, Identification in Closed Loop, Subspace Identification: Deterministic and Stochastic Systems, Identification in Continuous LTI systems, SRIVC, Generalized Smoothing Approaches.
System Identification Theory		
CH6480	**2**	History of Catalysis and Its Industrial Applications; Adsorption processes: Physical, chemical and dissociative adsorption; Desorption process; Kinetics and mechanism of catalytic reactions; Transport processes in catalysis: Mass and heat transfer in catalysis; Types of catalytic material and brief overview of their synthesis procedure; Poisoning, promotion, Deactivation and Selectivity of catalysts; Catalyst surface characterization: Physical and Chemical methods; Case Studies of Catalytic Applications.
Principles of Heterogeneous Catalysis		
CH6550	**2**	Evaluation of thermodynamic properties using NASA polynomials; Calculation of equilibrium composition of a reacting mixture; Kinetics of gas-phase reactions; Kinetics of surface reactions; Adsorption isotherms; Development of governing equations for chemical reactors; solution of governing equations using numerical solvers.
Chemical Reactor Modeling		
CH6560	**1**	Overview of mineral processing in terms of separation methods for minerals; introduction, mineral processing overview, metals vs minerals; metallurgical accounting,
Mineral Processing		

mineral liberation, comminution and classification, dense medium separations, gravity separation, froth flotation.

CH6580 **2**
Advanced Mineral Processing
Introduction to mineral processing; Minerals and Mineralogy; Mineral circuits; Metallurgical Balances; Comminution theory and limitations; Models of comminution process; Rock breakage characterization; Grinding mills, designs and modeling; Classification; Dense medium separation; Gravity separations; Froth flotation.

CH6610 **1**
Fuel Cell Technology
Types of fuel cels, advantes and disadvantages of differen fuel cell types, fuel cell thermodynamics, electrode kinetics, charge transport, fuel cell charanterization, modeling of electrochemical processes.

CH6620 **1**
Intermolecular Forces
Thermodynamics of Inter-molecular Forces; Variety of forces between the molecules (Ionic, Polar, Induced Polar, Dispersion and H-bonding); Calculations and analysis.

CH6630 **2**
Membrane Separation Process
▷CH1050, CH3022
An overview of membrane separation process, membrane classification, chemistry, structure and characteristics and preparation; various membrane separations technology such as microfiltration, ultrafiltration, reverse osmosis, dialysis, electrodialysis, gas permeation, pervaoration, liquid membrane, and their applications in chemical, biotechnology, food, and biochemical industry.

CH6640 **2**
Optimization Techniques I
Concepts of optimization, formulation of optimization problems, unconstrained optimization, necessary and sufficient conditions, convexity, single and multi-variable optimization, constrained optimization, KKT conditions, numerical optimization, one dimensional area elimination and interpolation based methods, multi dimensional Newton's / Quasi - newton methods, evolutionary optimization, genetic algorithms, solving practical problems.

CH6650 **1**
Introduction to Stochastic Differential Equations
Brief review of Modern Probability Theory, Stochastic Processes, Examples of SDE, Ito Integal, Ito Formula, Solutions to SDEs, Numerical Methods for solutions.

CH6670 **2**
Theory Of stochastic Differential Equations
▷see syllabus
Construction of Wiener Process (Brownian Motion), Continuous Time Martingales, Martingale Convergence Theorem, Wiener Martingales, Supermartingale Decomposition, Local Martingales, Stochastic Integrals for square integrable martingales, Ito Integral, Ito Formula and its applications, existence and uniqueness of solutions to SDEs, strong and weak solutions, linear SDEs, Markov and Diffusion processes.
Pre-Req: Real Analysis, Probability Theory and some amount of Topology, Function spaces / Consent of instructor

CH6680 **1**
Drug Delivery Systems
Principles of drug delivery (diffusion, barriers, permeability, availability, effective dose); design of vehicles (matrix and reservoir systems); polymer-drug formulations; approaches for site-specific and targeted drug delivery; challenges in the delivery of sensitive biomolecules; routes of administration; introduction to pharmacokinetics and ADMET analysis.

CH6690 **2**
Energy Storage Systems
Introduction to energy storage, power density vs. energy density, electrochemical energy storage including batteries, supercapacitors and fuel cells, chemical energy storage including hydrogen storage and biofuels, thermal energy storage including phase change materials and cryogenics, mechanical energy storage including flywheels and compressed gas, discussion of viable technologies for commercialization with emphasis on environmental impact, cost and efficiency, advantages, disadvantages and applicability of various technologies.

CH6710 **2**
Concepts in Soft Matter Systems
Introduction to Soft Matter-Polymer, colloids, gels, surfactants and liquid crystals. Soft Matter Solutions - Thermodynamics and Phase transition. Elastic Soft Matter - Networks and Gels. Soft Matter Surfaces - Surface tension, wetting, surfactants, interaction between surfaces, polymer grafted surfaces. Liquid Crystals - structures and phase transitions. Soft Matter Dynamics - introduction to concepts.

CH6720 **2**
Basics of Nanosciences and Nanotechnology
Physical aspects of Nanosciences, Introduction to Nanomaterials, Synthesis of Nanomaterials, Carbon Nanomaterials, Nanofabrication Methods, Charactetrization of Nanomaterials, Applications of Nanotechnology, Health, social, ethical concerns of nanotechnology.

CH6730 **2**
Nature Inspired materials engineering
Nature inspired material engineering and design for applications such as environment, energy and healthcare applications, bottom up assembly techniques and production, gap between natural and nature inspired materials.

CH6750 **2**
Applied Statistics in Experimental Research

Data presentation (histograms, box/scatter plots, bar/line graphs, distributions); Sampling distribution of the mean; Confidence intervals; Hypothesis testing; Comparison of means (T-testing, One-way and two-way ANOVA); Multivariate analysis; Non-parametric testing methods (Sign, Wilcoxon); Theoretical probability distributions ; (Normal/Poisson/ Binomial/ Gamma/ Lognormal/ Exponential/ Beta); Regression analysis; Concepts of clustering techniques (K-means, Fuzzy); Feature extraction (Principal component analysis)

CH6760 **2**
Molecular Theory of Polymeric Fluids
▷CH5030,CH5070

Introduction to Polymers: History, Synthesis, Polymer architecture. Single Molecule Conformations: Models for representing long chain molecules, Model Predictions- radius of gyration, end-to-end distribution, Effect of excluded volume on chain conformation (SAW model), Free energy of a chain, Ideal and real chains under tension and compression, Experimental measurements - Light Scattering. Single Molecule (Chain) Dynamics: Unentangled Dynamics: Rouse and Zimm model , Entangled Dynamics: Tube model - phenomenological mean field, Conclusions: From molecules to macroscopic properties: Structure-property relationships in systems with long chain molecules.

CH6770 **2**
Introduction to Applied Statistical Mechanics

Review of probability theory; concepts and significance of energy; postulates of statistical mechanics; statistical interpretation of thermodynamics; microcanonical, canonical and grand canonical ensembles; Statistics for various problems (of complex fluids and molecular fluids); Response of complex fluids under external forces; non-Newtonian behavior, concept of complex viscosity, stochastic force and Langevin equation, free and constrained Brownian motion etc.

CH6780 **1**
Soft Computing in Process Modeling

Evolution of soft computing techniques; Detailed discussion on components of soft computing e.g. Neural networks (NN), Support Vector Machines (SVM), Fuzzy logic (FL), Evolutionary computation (EC), Meta-heuristic and Swarm Intelligence; Formal implementation of soft computing techniques on real life data in the form of projects.

CH6810 **2**
Computational Fluid Dynamics

Philosophy of CFD, Governing equations of fluid flow, Mathematical behavior of partial differential equations, Discretization, Transformation, Numerical solutions, Some simple CFD Techniques, CFD solutions of some simple flows.

CH6820 **2**
Nature Inspired Optimization

Basics of optimization, objective functions, constraints, principles of optimality, single and multi-objective optimization, Pareto optimality, nature inspired optimization techniques e.g. genetic algorithms, differential evolution, simulated annealing, ant colony optimization, artificial bee colony optimization, particle swarm optimization etc., comparison with classical methods, hands on using standard test functions and practical projects.

CH6830 **1**
Surface Interactions
▷CH6620 Intermolecular Forces

Applying the intermolecular forces to the surfaces and geometries, DLVO forces, Polymer Forces, Self Assembly

CH6840 **2**
Biomaterials Science and Engineering

Properties, design and applications of metals, ceramics, polymers, hydrogels; Mechanical testing of biomaterials; Viscoelasticity; Maxwell/Kelvin-Voigt models; Surface properties of biomaterials; Protein adsorption and isotherms; Cell-ECM interactions; Cell adhesion on biomaterials; Cell migration models; Inflammation and immune response

CH6860 **1**
Data Analysis Tools for Experimental Research

Probability density function, analysis of variance: One way and Two-way ANOVA, Non-parametric testing, correlation, regression, computation of distances, clustering and validation, introduction to principal component analysis

14.7 Department of Computer Science and Engineering

CS1310 **2**
Discrete Structures I

Concept of mathematical proof, logic, proof by contradiction, mathematical induction, constructive proofs, sets, relations.
Illustration of proof techniques in various mathematical topics.

CS1340 **2**
Discrete Structures II
▷CS1310

Combinatorics. Basic counting principles, inclusion-exclusion, binomial/multinomial coefficients, bijections, double counting, pigeon-hole principle, recurrence relations. Introduction to graphs. Degree, isomorphism, diameter, connectivity, trees, matchings, colorings, planarity.

CS1353 **3**

Abstract data types, Big-Oh notation, Basic data types - Stacks, Queues, Trees

Introduction to Data Structures
▷Programming

CS2233 **3**
Data Structures
▷CS1353

More data types. Dictionaries. Binary search trees, Balanced search trees, Hash tables; Heaps, Priority queues, Graphs

CS2323 **2**
Computer Architecture
▷ID1303, CS1353

The objective of the course is to teach the fundamentals of computer architecture to CSE undergraduate students. The course would cover the following topics:
- Instruction set architecture
- Micro architecture
- Architecture and performance
- Arithmetic operations in processors
- Enhancing performance with pipelining
- Memory subsystem - cache and virtual memory
- Input/output organization

CS2400 **1**
Principles of Programming Languages I
▷ID1303

Programming language syntax, basics of compilers, names, scopes and bindings, control flow, data types, subroutines and control abstraction. Various paradigms of programming languages.

CS2410 **2**
Theory of Computation
▷CS1310, CS1340

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

CS2420 **1**
Introduction to Complexity Theory
▷CS2410

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

CS2433 **3**
Principles of Programming Languages II
▷CS2400

Functional programming, Object Oriented programming, Logic programming, Lambda calculus, Concurrency, Scripting languages, Programming language semantics.

CS2443 **3**
Algorithms
▷CS1310, CS1340, CS1353

Algorithmic Design Paradigms, Divide and Conquer, Analysis for Divide and Conquer, Sorting, Greedy Algorithms. Dynamic Programming, Graph Algorithms (DFS, BFS, Topological Sort, Single Source Shortest Path, Spanning Trees, All Pair Shortest Path, Matching, Max Flow), FFT.

CS3303 **2**
Software Technologies
▷ID1303

Latest technologies like Java Script, JSP, Python, Android, Perl, etc., to design software artifacts.

CS3320 **1**
Compilers I

Syntax directed translators, Finite automata, Regular Expressions, Lexical analysis, Context free languages and grammars, Syntactic analysis, Bottom-up and Top-down Parsing, Syntax directed translation, Lex and yacc as tools for lexical analysis and parsing.

CS3423 **3**
Compilers II
▷CS3320

Review of compilation process, semantic analysis, intermediate code generation, runtime, code generation, introduction to simple machine independent optimizations.

CS3510 **1**
Operating Systems I
▷ID1303, CS1353

History of OSs, Concurrency vs parallelism, Overview of Process management, Memory management, File systems

CS3523 **3**
Operating Systems II
▷CS3510

Process management: process states, process vs thread, scheduling algorithms, system calls, IPC. Process synchronization: Semaphores, Monitors, Deadlocks, Main memory: Paging system, File system; Virtual memory: demand paging and page replacement algorithms, File system implementation, Disk management, and I/O management; Case studies on Windows/Linux OSs.
Programming assignments related to OS features and their implementation. Further, students enhance functionalities of open-source toy OS named Minix3 by Andrew S. Tanenbaurm as part of the group projects.

CS3530 **1**
Computer Networks I
▷CS3523

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.

CS3543 **3**
Computer Networks II

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.

CS3550 **1**
Introduction to Database Management Systems

Purpose and evolution of database management systems, Relational model of data, Formal relational languages (relational algebra/calculus), SQL, Introduction to database design

CS3563 **3**
Database Management Systems (with Lab)
▷CS3550

Advanced SQL (procedures/functions/triggers), Database design and normal forms, Database application development, Storage structures and indexing/hashing, Query processing and optimization, Transactions, Lock-based concurrency control.

CS4443 **3**
Software Engineering (includes Lab)
▷ID1303, CS2233

Introduction to Software Engineering: Importance, challenges, approaches. Software Processes.
Requirements Engineering, Software Architecture, Planning, Design, Coding, Testing, Software Project Management, Advanced topics like Formal Methods in Software Engineering

CS5020 **3**
Pattern Recognition

Basics of pattern recognition, Bayesian decision theory, Classifiers, Discriminant functions, Decision surfaces, Parameter estimation methods, Hidden Markov models, dimension reduction methods, Fisher discriminant analysis, Principal component analysis, Non-parametric techniques for density estimation, non-metric methods for pattern classification, unsupervised learning, algorithms for clustering: K-means, Hierarchical and other methods

CS5030 **3**
Advanced Topics in Data Management

Parallel and distributed database systems. Advanced query processing and optimization - Volcano optimizer, decorrelation techniques, holistic optimization of database applications. Adaptive query processing. Streaming databases. Data warehousing and OLAP. Spatial databases and indexing of spatial data. XML.

CS5040 **3**
Linear Optimization

Linear programming, linear algebra, geometry of polyhedra, the simplex method, duality, primal dual algorithms, opt: applications to integer linear programs.

CS5060 **3**
Advanced Computer Networks

Basics of Computer Networking, TCP/IP protocol stack, Local Area Networks (Ethernet, Wi-Fi), Network Management, Network Security, Multimedia Transport, Next generation Internet architectures, Green Communication Networks, and Data Center Networking. Performance studies using QualNet simulator and lab assignments using Seattle GENI testbed.

CS5120 **3**
Probability in Computing

Basic probability, random variables, expectation, concentration inequalities, with algorithmic applications, Markov chains, random walks, applications to sampling and approximate counting.

CS5130 **3**
Cryptography

Basic cryptanalysis, perfect secrecy, number theory - Euclid's algorithm, Chinese remaindering, private key encryption (DES), linear cryptanalysis, public key cryptography, Diffie-Hellman protocol, RSA, secret sharing, hash functions, authentication, digital signatures, zero knowledge proofs.

CS5190 **3**
Soft Computing

Competitive learning models: Principle Component Analysis (PCA); Self-organizing maps (SOM); Information theoretic methods: Entropy, mutual information, K-L divergences; Independent component analysis (ICA), Maximum entropy method; Pulsed neural networks: Spiking neuron model, Integrate-and-fire neurons; Fuzzy Logic and Fuzzy systems, Fuzzy neural networks, Fuzzy K-means algorithm; Genetic Algorithms: Evolutionary computation, Genetic operators

CS5200 **3**
Approximation Algorithms

NP-hardness and approximation, approximation ratios and schemes, greedy algorithms, set cover, linear programming and rounding, primal-dual method, FPTAS for knapsack problem, bin packing, Euclidean TSP, introduction to hardness of approximation.

CS5230 **3**
Visual Recognition

Introduction to Representation, Learning, Detection, Recognition of objects, activities and their interactions from images and videos; Human visual recognition system;
Recognition methods:
Low-level modeling (e.g. features), Mid-level abstraction (e.g. segmentation), High-level reasoning (e.g. scene understanding); Detection/Segmentation methods; Context and scenes, Importance and saliency, Large-scale search and recognition, Egocentric vision

systems, Human-in-the-loop interactive systems, 3D scene understanding.

CS5290 **3**
Computer Vision

Students successfully completing this course will be able to apply a variety of computer techniques for the design of efficient algorithms for real-world applications, such as optical character recognition, face detection and recognition, motion estimation, human tracking, and gesture recognition. The topics covered include image filters, edge detection, feature extraction, object detection, object recognition, tracking, gesture recognition, image formation and camera models, and stereo vision.

CS5300 **3**
Parallel and Concurrent Programming
▷CS2233, CS3523

This course will provide an introduction to parallel and concurrent programming. It will focus both on correctness and efficiency of multi-threaded programs.
Introduction; Mutual Exclusion; Concurrent Objects; Foundations of Shared Memory; Consistency condition for concurrent objects: Sequential consistency, Linearizability; Consensus; Universality; Spin Locks; Multi-thread Linked Lists; Queues and Stacks; Counting; Hash Sets; Futures and Work-Stealing; Barriers; Transactional Memory; Parallel Graph and Marix Algorithms

CS5310 **1**
Advanced Operating Systems for Pervasive Computing
▷CS3523

- Introduction to Advanced OS Systems and Architecture
- Linux Kernel Frameworks and Infrastructure
- File-System Interface and Implementation
- Linux I/O Systems

CS5311 **2**
Pervasive Computing Lab
▷CS3523

- Linux Kernel Frameworks and Infrastructure
- Multimedia Framework Architecture
- Network Framework
- Graphics and UI Frameworks
- Web Framework
- Application Development
- Introduction to IoT

CS5320 **3**
Distributed Computing
▷CS2233, CS3510

Termination Detection Algorithms; Reasoning with Knowledge; Distributed Mutual Exclusion Algorithms; Deadlock Detection Algorithms; Global Predicate Detection; Distributed Shared Memory; Checkpointing and Rollback Recovery; Consensus and Agreement; Failure Detectors; Distributed file servers; Distributed programming environments: Communication primitives, selected case studies. (Note: Some topics may be added/deleted to suit specific offerings of the course)

CS5330 **2**
Introduction to Statistical Natural Language Processing

Probability Theory : Probability space, Random variables, probability distributions, joint and conditional distributions. Information Theory : Entropy, mutual information, divergences, Hypothesis testing.
N-gram and continuous space language models, distributed representations, probabilistic taggers and sequence labeling (HMM, maximum entropy models, conditional random fields), probabilistic parsing and structured prediction, probabilistic topic models, statistical machine translation.

CS5343 **3**
Computer and Network Security
▷CS3543, CS3523

It covers foundations of cryptography, system security, network security, Wi-Fi security, web security, mobile platform security with hands-on assignments and projects.

CS5350 **2**
Bayesian Data Analysis
▷Any basic course in Probability

Course Outline: Bayesian data analysis fits a probability distribution over the data and summarize the results by a probability distribution on the parameters of the model and on unobserved quantities. Bayesian models allow the incorporation of prior information and domain knowledge which helps to better model the data and observations. This is especially useful for applications such as healthcare and computational biology with limited data availability.
The course will cover various topics on bayesian data analysis such as single and multi-parameter models, regression models, hierarchical models, generalized linear models, spatio-temporal models, bayesian decision theory, Model selection, Bayesian inference algorithms based on Monte Carlo methods, variational inference, quadrature and expectation propagation, Bayesian non-parametric approaches such as Gaussian processes and Dirichlet processes, Point processes, Bayesian optimization and Bayesian deep learning.

CS5360 **3**
Advanced Computer Architecture

This course will cover several state-of-the-art and emerging topics in computer architecture, including multicore processor architecture, GPUs, CPU-GPU heterogeneous system, multi-core cache/memory architectures and resource management techniques, emerging memory technologies, processor power management techniques. The students are also expected to review and critique one recent research paper during the course.

CS5570 **3**

Groups, rings, fields; applications in RSA, polynomial factorization, secret sharing,

Algebra for Computer Science		error-correcting codes etc.
CS5580 Convex Optimization - Theory	**3**	Convex Analysis: Convex Sets, Convex Functions, Calculus of convex functions, Dual characterizations of convex sets, convex functions. Optimality of Convex Programs: 1st order nec. and suff. conditions, KKT conditions Duality: Lagrange, Conic and Fenchel duality Standard Convex Programs and Applications: Linear and Quadratic Programs, Conic Programs: QCQPs, SOCPs, SDPs
CS5700 Text Processing and Retrieval	**3**	N-gram and continuous space language models, distributed representations, probabilistic taggers and sequence labeling, probabilistic parsing and structured prediction, probabilistic topic models, Indexing document collections, Query-document scoring using Vector space model, Language Model, Evaluation metrics for ranking, Document classification.
CS6013 Advanced Data Structures and Algorithms	**3**	Dictionaries – Binary search trees, Probabilistic analysis of BST, Balanced search trees, Skip lists; Universal hash family, Hash tables; Heaps, Priority queues, Algorithmic Design Paradigms- Greedy algorithms, Dynamic programming, Divide and conquer, sorting, Randomized algorithms, Average case analysis, Lower bounds, Amortized Analysis, Graph algorithms- DFS, BFS, Topological sorting, Spanning trees, Shortest paths, Bipartite matching, online algorithms.
CS6140 Video Content Analysis	**3**	Introduction to video content analysis, feature extraction, video structure analysis -shot and scene segmentation, content based video classification, video abstraction - skimming and summarization, event detection and classification, indexing for retrieval and browsing, Applications -Movie and sports video analysis, news video indexing and retrieval etc.
CS6180 Systems Security	**3**	Understand the fundamental principles of access control models and techniques, authentication and secure system design. Have a strong understanding of different cryptographic protocols and techniques and be able to use them. Apply methods for authentication, access control, intrusion detection and prevention. Introduction Motivating examples, Basic concepts: confidentiality, integrity, availability, security policies, security mechanisms, assurance.Access to the System, Discretionary Access Control, Passwords for File Access, Capability List, Owner/Group/Other, Access Control Lists, Trojan Horse Threats, Mandatory Access Control, Security Models, Role of a Security Model , Practical Applications of a Model, Types of Security Models, Characteristics of a Security Model, State-Machine Models, Examples of a State Machine Model, Adding Constraints to State-Machine Access Models, The Bell and La Padula Security Model, Information-Flow Models, Informal Model-to-System Correspondence. Mapping the Functions, Mapping the Variables, Unmapped Functions and Variables Firewalls and Web Security - Packet filters, Application level gateways, Encrypted tunnels, Cookies, Web security problems Introduction to cryptography, Secret key cryptosystems, Modular Arithmetic and Public key cryptosystems, Public key cryptosystems, Diffie-Hellman and RSA Message digests, digital signatures, Identification and authentication, Passwords, Biometrics, One-time passwords and challenge response schemes, Kerberos, Kerberos, SSL, SSH.
CS6190 Advanced Topics in Cryptology	**3**	Reading research papers in the area of cryptology and understanding the state of the art in the subject.
CS6200 Advanced Topics in Formal Methods	**3**	This course will involve a reading of important papers in the area of formal methods. It will be preceded by a review of pre-requisite concepts in logic, verification, model checking and automata theory.
CS6210 Advanced Machine Learning	**3**	Generative models for discrete data, Gaussian Models, Bayesian Statistics, Linear Regression, Logistic Regression, Directed graphical models (Bayes nets), Mixture models and the EM algorithm, Sparse linear models. Kernels: Kernel functions, kernel trick, Support vector machines (SVMs), Kernels for building generative models. Markov and hidden Markov models, State space models, Undirected graphical models (Markov random fields), Monte Carlo inference, Markov chain Monte Carlo (MCMC) inference, Graphical model structure learning, Deep learning, Boosting, On-Line learning, Decision Trees, Ranking. Compressive Sensing and Dictionary Learning: Pursuit algorithms and applications for imaging and vision.
CS6220	**3**	This course aims for students to (1) understand and apply fundamental mathematical

Computer Vision		and computational techniques in computer vision and (2) implement basic computer vision applications. Students successfully completing this course will be able to apply a variety of computer techniques for the design of efficient algorithms for real-world applications, such as optical character recognition, face detection and recognition, motion estimation, human tracking, and gesture recognition. The topics covered include image filters, edge detection, feature extraction, object detection, object recognition, tracking, gesture recognition, image formation and camera models, and stereo vision.
CS6230	**3**	Introduction to Optimization, Convex Sets, Convex Functions, Lagrange Duality, Convex Optimization Algorithms, Second-order cone models, Semi-definite programming, Semi-infinite programming, Minimax, Sublinear algorithms, Interior Point Methods, Active set, Stochastic gradient, Coordinate descent, Cutting planes method, Applications to Image/Video/Multimedia Processing Pre-Req: Basic Machine Learning or Soft Computing course
Optimization Methods in Machine Learning ▷see syllabus		
CS6300	**3**	This advanced graduate level course will focus on a melange of selected topics in Compiler Optimizations. It is mostly a research based course where the registrants will focus on studying state-of-the-art algorithms, in a traditional setting or in the polyhedral compilation: studying and improving the existing algorithms published in top compiler conferences or the ones implemented in LLVM, Polly, PPCG, Pluto, etc.
Topics in Compiler Optimizations ▷CS3020, CS6240, CS6250		
CS6310	**1**	Introduction to Quantum Mechanics—the mathematics and physics; Quantum Circuits; Deutsch and Deutsch Jozsa algorithms
Quantum Computing I ▷BTech CSE 3rd year+		
CS6320	**1**	Quantum Algorithms: Shor's Integer Factoring, Grover's unordered search, Hidden Subgroup Problem for various groups, Other Quantum Algorithms
Quantum Computing II ▷CS6310		
CS6330	**1**	Quantum Error Correction, Quantum Information Theory and Quantum Cryptography
Quantum Computing III ▷CS6310, CS6320		
CS6350	**3**	This advanced graduate level course on combinatorics will focus on selected topics such as extremal combinatorics, probabilistic techniques, algebraic method in combinatorics etc. Pre-Req: Self-assessment. Prior approval of the course instructor is needed
Topics in Combinatorics ▷see syllabus		
CS6360	**3**	This advanced graduate level course on machine learning will focus on selected topics such as deep learning, probabilistic graphical models, optimization in machine learning, etc. The course assumes that the student has basic knowledge in machine learning, and will have a research focus. The objective of the course will be to get a deeper understanding of machine learning algorithms, especially those that are highly relevant for contemporary real-world applications. Pre-Req: Self-assessment: Should have prior knowledge in machine learning, either through IIT-H or Coursera courses. Prior approval of the instructor is needed.
Advanced Topics in Machine Learning ▷see syllabus		
CS6370	**3**	• Storing, indexing and querying document data • Scoring, term weighting document relevance estimation • Text classification and clustering • Probabilistic information retrieval • Ranking in a Graph Pre-Req: Data Mining / Machine Learning. Prior approval of the course instructor is needed.
Information Retrieval ▷see syllabus		
CS6380	**1**	• Real-world compilers have complex algorithms and optimization strategies implemented in them, along with having various implementation techniques that are language/architecture independent as well as having language/architecture specific features. All the above makes engineering modern real-world compilers also a hard software-engineering problem. • This 1 credit course will focus on understanding these issues, taking the popular LLVM compiler as a case-study. • The following are some of the areas that we plan to study: • Analyses/Transformations in LLVM. • Methods of adding new FrontEnds and BackEnds to LLVM. • Introduction to Pass-manager of LLVM. Adding new passes. Pre-Req: CS2430 (Principles of Programming Languages 2) or Equivalent for B.Techs. An advanced compiler course for M.Techs and PhDs. An aptitude for large software. Prior consent of the instructor.
Introduction to Compiler Engineering ▷see syllabus		
CS6390	**1**	Small-Space Algorithms, Estimating Statistical Properties, Distance Estimation,

Enabling Large Scale Data Analytics: From Theoretical Foundations to Practice
▷see syllabus

Clustering and Ranking, Algorithms over Massive Networks, Learning Algorithms
Pre-Req: Data Structures and Algorithms, Any course on Probability and Statistics

CS6400 1
Constraint Solving
▷see syllabus

Many real world problems reduce to solving a set of constraints. From time table scheduling to inventory management and fault localization to efficient resource utilization, it all ultimately boils down to expressing these problems as a set of constraints. Not only it is at the heart of most of the problems in operation research but constraint solving has applications ranging from computational biology to program analysis. These applications use the constraint solvers mostly as a black box. However, one can gain tremendously from the study of constraint solvers and the techniques they employ so as to adapt them to the problem at hand.
This course will attempt to study the underlying techniques employed by modern day constraint solvers. In particular, solving techniques behind SAT, MaxSAT, Pseudo-Boolean constraint solving will be studied. In addition, this course will also attempt to take a look at SMT (Satisfiability Modulo Theories) solving.
Pre-Req: Data Structures, Object-oriented programming, Theory of computation, Discrete mathematics, Algorithms

CS6410 3
Software Verification
▷see syllabus

Course Outline: Software has penetrated almost every aspect of our lives. From banking applications to air traffic control, from pacemakers to smart cars uses some software component. It is therefore of paramount importance that these software work correctly. In this course, we will study various ways to formally analyze and reason about software systems.
The course may cover topics such as Hoare logic, abstract interpretation, abstraction refinement, k-induction, symbolic execution, variants of bounded model checking for sequential as well as concurrent programs such as loop bounding, context bounding and reorder bounding. Use of formal techniques for software testing and reasoning about termination can also be covered
Pre-Req: Data Structures, Object-oriented programming, Theory of computation, Discrete mathematics, Algorithms, Compilers

CS6430 3
Computational Number Theory and Algebra
▷Discrete maths, Algorithms

Finite fields, quadratic residues, primality testing, polynomial factorization, applications in cryptography/coding theory. Optional topics: Integer factoring, lattices.

CS6440 2
Advanced Computer Architecture
▷CS2323

This course will cover several state-of-the-art and emerging topics in computer architecture, including multicore processor architecture, GPUs, CPU-GPU heterogeneous system, multi-core cache/memory architectures and resource management techniques, emerging memory technologies, processor power management techniques. The students are also expected to review and critique one recent research paper during the course.

CS6450 3
Advanced Topics in Computer Vision
▷see syllabus

This course will discuss advanced topics and current research in computer vision. Students are expected to read papers selected from various subareas such as deep learning, segmentation and grouping, object and activity recognition, scene understanding, and vision and language. Approaches for learning from image and video data will be covered and include topics from convolutional neural networks, recurrent neural networks, structured predictions and others. The course will be a mix of lecture, student presentation and discussion.
Pre-Req: Undergraduate- or graduate-level machine learning or computer vision; A good working knowledge of C/C++, Java, Python or Matlab

CS6460 1
Introduction to Deep Learning for Vision
▷see syllabus

This course will introduce students into the complex, abstract world of computer vision and deep neural networks. Topics covered will include: Basics of deep learning and its history, State-of-the-art deep neural net models in computer vision; Specific tools and packages to train these deep nets; and what it takes to train and run these models in the real-world.
Pre-Req: Basic knowledge of machine learning and computer vision; Linear Algebra, Probability; A good working knowledge of C/C++, Java, Python or Matlab

CS6483 3
Constraint Programming

This course will study the underlying techniques employed by modern day constraint solvers. In particular, solving techniques behind SAT – such as chronological and non-chronological backtracking, conflict-driven clause learning. Various encoding techniques for cardinality constraints as well as analysis of size of the encodings for MaxSAT and Pseudo-Boolean constraint solving will be studied. In addition, this course may also attempt to take a look at SMT (Satisfiability Modulo Theories) solving. (Note: Some topics may be added/deleted to suit specific offerings of the course)

CS6490 **3**
Hardware Architecture for Deep Learning
▷an introductory course on computer architecture or an introductory course on machine/deep learning

Approximate computing and storage, low-precision deep-learning (DL) accelerators, FPGA-based DL accelerators, GPU-based DL accelerators, memristor-based DL accelerators, addressing memory-bottleneck in DL accelerators, deep learning on embedded system platforms such as Jetson, hardware-acceleration of cognitive tasks such as autonomous driving, differences in hardware requirements for DL training and inference, DL on virtual machine and containers, architectural review of some recently-proposed DL accelerators (e.g., TPU).

CS6510 **3**
Applied Machine Learning

Classification (Naive Bayes, k-NN, SVM, Neural Networks, Decision Trees, Logistic Regression, Ensemble Methods), Regression (Linear, Non-linear, k-NN, SVR), Clustering (k-means, DBSCAN, hierarchical), Dimensionality Reduction (PCA, MDS, Isomap), Gaussian Mixture Models, EM, Feature Selection, Model Selection and Performance Evaluation (Cross-Validation, Bootstrap, ROC), Time series analysis methods

CS6660 **3**
Mathematical Foundations of Data Sciences

Matrices, Vectors and Properties; Vector Spaces, Norms, Basis, Orthogonality; Matrix Decompositions: Eigen decomposition, Singular Value Decomposition; Differential Calculus: Derivatives and its significance, Partial derivatives; Optimization of single variable and multiple variable functions: Necessary and sufficient conditions; Real problems as optimization problems: Formulation and analytical solutions; Finding roots of an equation: Newton Raphson Method; Optimization via gradient methods; Probability basics, density function, counting, expectation, variance, independence, conditional probability, Poisson process, recurrences, Markov chains

CS6670 **3**
Topics in Data Mining
▷CS3560, CS3140

Data Preprocessing, Data Warehousing and OLAP, Mining Frequent Patterns and Associations, Classification, Cluster Analysis, Mining Complex Types of Data (Sequence Data, Graphs, Social Networks, etc.), Text Mining, Stream Data Mining

14.8 Department of Chemistry

CY1017 **1**
Environmental Chemistry-i

Know our environment (atmosphere composition and behavior, ecosystem, flow of energy and nutrient cycles, sustainability), Know about global warming (greenhouse gases, results of global warming), concise 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.

CY1020 **1**
Dynamics of Chemical Systems-i

Introduction to Chemical kinetics, Basics in Electrochemistry: Electrochemical Principles and Reactions, Basic concepts of electrochemical cells and batteries, Historical background of quantum hypothesis, Wave equation, Postulates, Schrodinger equation and introduction to simple solvable problems

CY1021 **2**
Dynamics of Chemical Systems-ii

Advanced insights into chemical kinetics including Collision theory of reaction rates, Transition State Theory, Energy Storage Systems (e.g. Lead-Acid, Lithium Ion Batteries, Fuel Cells and Supercapacitors): fundamentals to applications, detailed understanding of Corrosion, electroplating, electroless plating, Particle in box, Harmonic Oscillator, Rigid rotor, Vibrational and rotational spectroscopy, Approximate methods, Atomic and molecular orbitals, Hybrid orbitals, Chemical bonding.

CY1030 **2**
Environmental Chemistry-ii

More about environment (chemistry of lithosphere, energy balance, sustainability and recycle), More on global warming (infrared absorption, molecular vibration, atmospheric window, residence time of greenhouse gases, evidences and effects of global warming), Deeper analysis of atmospheric pollution (Chemistry of CO, NOx, VOCs, SO2, Industrial smog, photochemical smog), Ozone depletion (production, catalytic destruction), Fate of organic/inorganic chemicals in natural and engineered systems (fate of polymers after use, detergents, synthetic surfactants insecticides, pesticides etc. after use), impact on physical-chemical properties of environmentally relevant compounds, Aspects of transformations in atmosphere (microbial degradation of organics- mechanism of action of DDT or analogues, environmental degradation of polymers, atmospheric lifetime, toxicity), Future challenges (CO2 sequestering, Nuclear energy), a project on environment related topic.

CY1031 **2**
Laboratory Experiments

Basic chemistry related experiments: synthesis and characterization of organic molecules such as paracetamol, aspirin and acetanilide; Chemical analysis of organic compound; quantitative experiments on the estimation of phenol, sodium in cement, percentage of iron content in haematite; Determination of Hardness of Water; Synthesis of potash alum from scrap aluminium a recycling of aluminum waste, experiments on reaction kinetics; Phase Rule; Acid Strength in Citrus Fruit; Formation Constant of KI3

14.9 Department of Design

DS1013 **1**
Elements of Design
The course will look at the building blocks of design such as space /point / line/ shape / value / texture / form. To understand perceivable and non-Perceivable elements of Design, Explorations on individual elements

DS1020 **1**
Design, Culture and Society
This course aims to employ the framework of design to look at social and cultural systems and practices. It also locates design as an evolutionary process within the social and cultural milieu. The course intends to bring out, both the self-organised and the intentional dimensions of Design.

DS1033 **1**
Color
Basic colour theories and application of color modes such as additive and subtractive colours, and different colour models. Application of colour and colour mixing. (Hands-on course)

DS1043 **1**
Environmental Exposure
Exposing students to the social and cultural environments of the rural/ urban realities and observing their behaviour in various contexts.

DS1053 **2**
Introduction to Design (lecture Series)
A lecture series on various aspects of design to introduce the students to various design diciplines such as graphic design etc.

DS1063 **1**
Principles of Design
A course about various design principle such as rhythm, balance, contrast, symmetry, Emphasis, harmony, unity. Explorations on individual elements with respect to different Principles, mediums and styles.

DS1070 **1**
Evolution of Design
The course is an attempt to look at the history of design and major turning points that lead to what it is today. It also deals with history of art and design from pre historic to present. Understanding of design schools and key contributors for the evolution of design education and system.

DS1083 **1**
Digital Fabrication 1
Introduction to 3D printing as a design tool to execute your creative ideas. (Hands-on course)

DS1093 **1**
Form
Introduction to principles and elements of design. Basics of balance, rhythm, harmony, contrast, axis, scale, proportion, size, etc. Line, plane, volume, color, pattern, shape, size, space, texture and materials, etc., to start exploring form. Function and functionality understanding. Form and function correlation. Material explorations in 2D using wire, paper, etc.

DS1101 **3**
Workshop and Material Explorations
The course explores different materials and methods for design. (Hands-on course)

DS1113 **2**
Product Design
Design philosophy, Products, Product Design Process. Brief overview of morphology of Design, Phases in Design cycle, Identification of needs, conceptual design, Concept generation, screening, scoring, detail design, Design for manufacturing and Assembly (DFMA), product economics

DS1123 **2**
Animation
This course introduce to the principles of animation and how to physically achieve it using classic animation methods. The participant is also introduced to diverse techniques and materials in animation such as claymation, sand animation, stop motion etc. The course can extend to designing characters for animation.

DS1130 **2**
Film Appreciation
This course intends to practically help participants to read a film beyond its on-screen meaning to understand its creative structure through the intentions of its makers and their effort. The course will give them a first-hand introduction on cinematic elements such as narrative, mise-en-scene, editing, cinematography and sound to help them understand how their sum contributes to the whole experience.

DS1144 **2**
Digital Fabrication 2
Advanced 3D modeling techniques with 3D Printing concepts Vaccum casting, Laser cutting and CNC modeling. 3D Printing with multi-color and multi material designs. Project involving ideation, design and final fabrication using 3D printing.

DS1153 **2**
Interaction Design
An introductory course in interactive media and its possibilities to students of any background. How content can be generated, effectively create the information architecture and user experience in the digital medium.

DS1163 Graphic Design	**2**	The course introduce to the building blocks of visual communication, typography and graphics. Basic Graphics introduces to abstracting visual information in the form pictograms, icons etc and together with typography it can create visual experience.
DS1173 Photography	**2**	The course introduces you to the powerful medium of photography, the technical aspects related to the equipment and delivery of the content. It introduces to studio photography using artificial lights and street photography in natural light. It also introduces to composition and various storytelling techniques in photography.
DS1183 Design Process	**1**	Basics of Design Methods, Various theoretical insights on methods, Empirical and Visual methods, Methodology for documenting collective Activity, Design research and its argumentative grammer.
DS1193 Design Drawing 1	**1**	Deals with different types and techniques of drawing and visualization. Understanding of various art materials, usage and visualization techniques. Medium specific explorations and presentation.
DS2013 Material Explorations	**2**	Introduction to traditional and new materials. Understanding of basic hand tools and simple machinery. Knowledge on usage, methods and techniques to achieve specific results. Hands on experience of sequential processes by explorations of different types and properties of material.
DS2023 Applied Ergonomics	**1**	Man-Machine Interface, Anthropometry - techniques to measure anthropometric dimensions, and other attributes like vision and force parameters, Displays and Controls, Perceptual and Cognitive aspects in design, Sensory abilities, information processing, response limitations, physical/physiological limits, workplace evaluation.
DS2033 Design Computing	**1**	This course expose to the basic building blocks of creating a digital experience. Learning HTML and coding is an essential component to understand the possibilities and limitations of the medium, for the designer to optimise user experience in digital medium.
DS2043 Sound Design	**1**	The objective of this course is to introduce students to the process of recording, acquiring, manipulating or generating audio elements for diverse fields such as animation, advertising, film, performances, experiences etc.
DS2050 Semiotics	**1**	Introduction to Semiotics elaborate on signs and symbols, as they communicate things spoken and unspoken. Its relevance in design and at large in culture and society will be discussed.
DS2063 Advanced Product Design	**2**	Morphology of Design, Phases in Design cycle, Identification of needs-Techniques-User interviews, questionnaires, Group feedback, conceptual design - idea generation creative methods, Lateral thinking, Brainstorming exercise, Design by analogy methods - Bio-inspired Design, Innovation in Design, detail design, idea generation - brainstorming, analogical reasoning, Theory of Inventive problem solving (TRIZ), Design for manufacturing and Assembly (DFMA), Failure Modes Effects Analysis, Product Planning and Marketing.
DS2073 Advanced Graphic Design	**2**	This course extends to creating powerful imagery merging text and images for a variety of visual media from print to digital.
DS2083 Automobile Design Voyage 1	**2**	Taking it to next level by development of form, function and mechanism in parts and totality for the solution of mobility. Extensive research work in trend analysis, 3D printing application in mobility components solutions, and design of individual parts for innovative solutions. Bringing in engineering solutions and novelty.
DS2093 Elements of Film Making	**2**	The course introduce to the elements that make up the film such as creating script, storyboarding, art direction, cinematography, lighting, sound, editing etc. It introduces to the technical aspects through hands-on experience in each of these elements.
DS2103 Printing Technique	**2**	The intention is to understand various printing methods from letter press, screen printing to offset printing, and how they are different from each other. The course intends to give hands-on experience in each of these methods.
DS2113 Interaction Design 2	**2**	An introductory course in interactive media and its possibilities to students of any background. How content can be generated, effectively create the information architecture and user experience in the digital medium.
DS2123 Storyboarding	**2**	The medium of illustration to create/ plan visual sequences/ narratives for a diverse set of media from graphic novels, animation to film. It takes into consideration the characters and their interaction with space/ environment and light.
DS2133	**2**	This course takes a deeper look at aspects of artificial lighting in a studio setup to shoot

Product Photography and Studio Lighting	products and people.
DS2213 **1** Design for Sustainability	The course intends to offer in-depth understanding and extensive analytical ability to map/assess LCA of products and reverse engineer design and manufacturing processes in order to minimize impacts and emissions.
DS2223 **1** Mental Model and Affordance	The course is an introduction to understand physical model of user behaviour and translate it into an online experience. It introduces to the design process starting from mapping the user behaviour to understanding the contemporary conventions in creating user affordance in online experience.
DS2232 **2** Illustration	The course introduce to the powerful medium of illustration which is an integral part of the visual communication. It exposes to the diverse uses and styles of the medium to create powerful content in various media from editorial content, children's books, storyboarding, animation, graphic novels and many more.
DS2243 **1** Data and Information Visualization	We are living in the age of information explosion. Designers can play an active role in making the huge volume of information intelligible to users. The objectives of the course are to understand the increasing quantity and complexity of data and information produced, to filter information, organize, represent, establish relationships and discern patterns, to develop inspiring and stimulating solutions to contextualize information that simultaneously inspire, inform, entertain and even encourage critical thinking.
DS2250 **1** Indian Aesthetics	This course intends to introduce and discuss art history and art movements of the world and specifically that of Indian subcontinent to understand its influences in Design.
DS2263 **1** Universal Design	As per definition, Universal Design is the design and composition of an environment so that it can be accessed, understood and used to the greatest extent possible by all people regardless of their age, size, ability or disability. The course is an attempt to understand the need for such services, products and environments and design and innovate for the same.
DS2272 **1** Form Language	Product form evolution, analogy and case studies. Cross referencing of form derivations from famous designers and architects and its morphology. Case example studies of contemporary designers and their uniqueness and identity analysis of their designs. Cross-referencing and cross-breeding of design language with materials. An unique approach of understanding form.
DS2283 **2** Creative Coding	The goal is to create visually expressive and experimental digital experiences to create games, entertainment, art installations, projections, sound art, advertising, tangible experiences, product prototypes, and much more.
DS2293 **2** Advanced Typography	The course extends to understand character of fonts in detail to create new fonts for a variety of media and in different languages.
DS2313 **1** Cognitive Ergonomics	Course is an introduction to understand human-system interaction compatible with human cognitive abilities and limitations, particularly at work.
DS2333 **2** Nature and Form	Nature has the largest pool of perfectly working resources of all types. Course intends to take nature based inspirations and explore for possible design solutions in various needs. Fundamentals of principles of design found in nature. Explorations in form, function and mechanism would be the major drive. Nature based design principles such as golden ratio, etc. and case examples of works of famous designers and architects.
DS3013 **2** Virtual Environments in Design	To introduce tools and methods for creating 3D virtual environments and interact through visual, haptic and aural modalities. Also Introduce basics of visual and haptic perceptions, devices, Virtual Reality (VR) technology and applications. The course also aims to provide hands-on experience of creating simple 3D scenes using open source 3D graphics library - OpenGL/Unity3D for graphics and OpenHaptics/H3DAPI for Haptic interactions.
DS3093 **2** System Design for Sustainability	The course intends to introduce state of the art knowledge resource from the field of principles of systemic sustainable design approach. It caters to products as well as services around the need of people in order to workaround an optimized solution. It integrates S-PSS (sustainable product service system) approach and tools from LeNS, Polimi Italy (learning network on sustainability) to introduce issue based analysis, methods and tools for assessment and correction, etc.

DS3113 Digital Storytelling	**2**	How information can be represented and narrated in the age of digital experience for a variety purposes from education to journalism. Convergence of media in digital platforms have made it challenging for designers to create sustaining story experiences in digital media. The course intends to create compelling narratives using possibilities of multimedia in digital world.
DS3120 Design and Philosophy	**2**	Design practice in its engagement with material and behavioural worlds and in the act of shaping and structuring, contains and demands certain attitudes, positions and dispositions in relation to those worlds. Various philosophical schools and perspectives have and continue to influence, lead and inspire design practice. This course aims to provide the course participants with an opportunity to reflect, explore and examine various philosophical perspectives at work in and through the notion and practice of 'design'.
DS3133 Digital Heritage	**2**	The physical experience obtained when people visit the monuments, will be translated to the digital medium and the aim is to recreate the digital experience much nearer to the original experience of the physical monument. And to create a knowledge base for the future, parallely communicating the form, style, design, culture and history to next generation. This is achived by using hiend technology like photogrammatry, laser scanning, 360 photography and high resolution photography.
DS3143 Design for Education	**2**	The course looks at intervention through design tools, thinking and pedagogical methods to improve education. Creating innovative methods to make education fun for all. Analogue and digital methods are explored.
DS3153 Display and Control	**2**	The course intends to design ergonomic visual display of controls in various products, complex machinery and transportation, keeping the user at ease by communicating the right action.
DS3163 Documentary Photography	**2**	This course is a hands on experience through taking challenging topics from society and visually documenting through photography. It includes research and understanding of social circumstances, how to approach stakeholders and effectively tell a visual narrative.
DS3173 Moving Images	**2**	Storytelling using animation, film and motion design to communicate and entertain the audience. It runs through the various process of production of the medium chosen to tell the story.
DS3183 Automobile Design Voyage-2	**2**	The course intends to deliver skills of visualization and design delivery for the need of mobility. Utilizing core subject knowledge competence with creative blend for automobile design and development of mobility solutions across personal to mass transportation. This advanced course intends to develop a full-scale model.
DS3193 Technically Complex Product Design	**2**	The course looks at the design and development of advanced products and machinery which also requires substantial inputs from engineering disciplines as well.
DS3203 Participatory Design	**2**	This course expands horizons for communication designers to convert the medium from passive to active. Earlier user was a passive entity in the process of information dissemination. How to co-create compelling information experiences with the participation of the audience is the aim of the course. The outcome could be in the form of games, performance, live data visualisations etc transcending physical experience to digital experience.
DS3213 Contemporary Photography	**2**	An advanced photography course to understand develop newer storytelling practices within the area of photography. Various experimental methods are explored.
DS3223 Advertisement and Branding	**2**	The course objective is to understand the market to create strong identity and communicate brand values using diverse techniques of print, animation, film etc to create compelling messages.
DS3233 Environmental Design	**2**	Designing a conscious, pleasant environment in public and private spaces considering all aspects of sustainable practices in Space, Architecture and horticulture.
DS3243 Tangible Computing	**2**	A tangible user interface helps a person interacts with digital information through the physical environment. The purpose of TUI development is to empower collaboration, learning, and design by giving physical forms to digital information, thus taking advantage of the human ability to grasp and manipulate physical objects and materials.
DS3253	**2**	The course gives a broad perspective on applications of artificial Intelligence to advanced

AI in Design	computer based design systems. Applications of techniques like Machine learning, Rule based systems, expert systems, Natural Language Processing in the context of Design. Design generation, analysis and Interpretation through expert systems.
DS3263 2 Film Making	The course is a practical application of the elements that make up the film such as creating script, storyboarding, art direction, cinematography, lighting, sound, editing etc. How planning, costing and production work from scratch to create stories on screen.
DS3273 2 Product Graphics and Packaging	This course intends to expose to various packaging techniques and push further to create sustainable packaging practices for future. The course also expands to packaging presentation through product graphics for retail and other environments.
DS4013 2 Automobile Design Explorations	The course intends to deliver skills of visualization and design delivery for the need of mobility. Utilizing core subject knowledge competence with creative blend for automobile design and development of mobility solutions across personal to mass transportation. Elements of engineering, anthropometry, ergonomics, alternative energy systems, materials and styling would be used to amalgamate and come up with innovative ideas to address complex requirements. The course embraces the design and development process by user research, scenario study, applying new materials, utilizing cutting edge technologies to address the changing paradigm. Explorations and design process would be emphasized to come up with fresh ideas in initial stage. Further student would move to solve comfort, functional, safety and technical requirements and refine the design in physical and digital mediums for a final design solution. It is a challenging process to achieve good design and would require in-depth attention towards development of form, function and innovation for achieving future-ready rewarding mobility solutions. Lectures would be supported by hands-on exercises, field study, research and model making.
DS4016 1 Internship	Hands on practice with a design related institution to gain experience in design work space and practice. The work would be presented/displayed in front of a panel of design faculty to considered for credit work.
DS4020 2 Design Management	Essentially deals with the management of a design firm. Course looks at how design industry works and process and logistics can be managed Keeping in mind the peculiarities of this creative industry.
DS4023 1 Calligraphy	The course intends to deliver calligraphy as a quick but effective art form to express by words or art. It helps students, in writing skillfully by careful attention to shape, figure, strokes and structure of letters and learning its techniques with fineness. Learn to sync drawing movement by fingers while balancing the coherence of the typeface. Learn to draw using artistic inspirations, free but controlled flow and the rhythm which creates the sense of exotic lyricism in the text and art form.
DS4030 1 Intellectual Property Rights	An overview on intangible human creativity is protected through patents, trademarks, copyrights. Also look at the open licencing methods for creativity.
DS4033 1 Life Cycle Analysis	Like a living entity; every manufactured entity has various life-stages. It starts with the collection of raw materials or ingredients, processing / manufacturing, use, maintenance and after-life disposal. The LCA devises quantitative analysis of environmental impact, defragments all life stages, calculates embodied energy, analyzes impact on ecosystem of particular product / service / system in its entirety. It encompasses a holistic view of the chosen entity from sourcing to decomposition and all intermediate stages. LCA offers insights of the phases and interpretations of it provide feedback loop for the improvement. The course intends to deliver understanding of LCA and capacity to implement it for a given product / service / system. The course intends to undertake real life case studies for LCA. The areas could be based on student's background and interest such as buildings, industrial products, 3D printers, building materials (cement, concrete, bricks, steel, rubble, etc.), metals, civic waste, sewage, solid waste, landfills, electronic materials and components, semiconductors, chemicals (pharmaceutical, drug, dyes, lead, mercury, high toxicity compounds, heavy metals), medical waste, tannery, distillery, paper and pulp, food waste, bye-products, pollutants, VOCs, fertilizers, GHGs, SOx, NOx, Coal, hydrocarbons, etc., with biotic and abiotic resources.
DS4040 1 Professional Practice	This course covers the ethical, legal, and financial dimensions of working as a design professional.

DS4050 **1**
Entrepreneurship and Business Planning
This course intends to provide a glimpse of the business aspect of design. The aim is to equip the students with the skill of drawing up and proposing business plans and start-ups.

DS4060 **1**
Design Research
The peculiarities of research in understanding and practising design - the heuristic, creative and systematic approaches to doing research both in and through Design.

DS4073 **1**
Design Innovation
Encouraging the development of innovative methods, tools and products in various Design streams.

DS4080 **1**
Portfolio Skills
The course intends to give directions and feedback to suitably create a design portfolio encompassing the process and outcomes during the academic period.

DS4115 **15**
Final Semester Thesis Project
It's the culmination of all the theoretical and practical learning applied to a final project for which the output could be in the chosen specialised area by the student. There will be a thesis component and final product / prototype based on the chosen medium.

14.10 Department of Electrical Engineering

EE1010 **1**
Electric Circuits
Mesh and node analysis, Thevenin, Norton and other network theorems, two port Networks, Sinusoidal Steady state analysis of R-L-C circuits, Filters, Transient Circuit analysis through Laplace transform techniques.

EE1020 **1**
Magnetic Circuits
Coupled circuits, Transformers

EE1030 **2**
Network Theory and Synthesis
Impulse and step response of electrical circuits, Transformation methods and its applications in network analysis, frequency response of electrical circuits, Single and Double-Tuned circuits, Two-port network analysis, Analysis of ladder networks, Realizability of electrical networks, Synthesis of single port electrical circuits, Transfer function synthesis of electrical networks, Filter design.

EE1040 **1**
Matrix Analysis
Matrices and vectors, determinants, singularity of matrices, rank, Eigen values, eigenvectors, and invariant subspaces, Vector norms and matrix norms.

EE1083 **2**
Introduction to Computing
Model of a computer; Basic programming constructs: types, statements, I/O, conditionals, loops, functions, class/object, builtins, modules (in Python with iPython or Jupyter); Debugging and Profiling; Libraries - string, numpy, pandas, scipy, matplotlib with examples in matrix manipulation, image analysis, optimisations, DSP; Python to C interoperability.

EE1093 **2**
Introduction to Computing
Model of a computer; Basic programming constructs: types, statements, I/O, conditionals, loops, functions, class/object, builtins, modules (in Python with iPython or Jupyter); Debugging and Profiling; Libraries - string, numpy, pandas, scipy, matplotlib with examples in matrix manipulation, image analysis, optimisations, DSP; Python to C interoperability.

EE1110 **1**
Applied Digital Logic Design
Boolean logic, truth tables, Combinational and Sequential Logic, K-Maps, Finite State Machine

EE1120 **1**
Digital System Design
Gate level design of Small Scale Integration (SSI) circuits, Modular combinational logic elements-Decoders, Encoders, Priority encoders, Multiplexers and Demultiplexers, Adders, Subtractors, Multipliers, division circuits, Complexity and propagation delay analysis of circuits, Sequential circuits - Latches, Flip-flops, Master-slave flip flops, Edgetriggered flip-flops, Models of sequential circuits - Moore machine and Mealy machine, Flip-flops - Characteristic table, Characteristic equation and Excitation table, Analysis and Design of sequential circuits, Modular sequential logic circuits- Shift registers, Registers, Counters and Random access memories, Design using programmable logic sequencers (PLSs), Serial adder for integers, Design of control units for multipliers/dividers

EE1150 **1**
- Concepts of embedded programming.

Embedded Programming	• Concepts of assembly language • Hardware-description language (VHDL/Verilog). • High-level synthesis (using Synopsys Synphony C Compiler) • Micro-controller programming: basic and advanced (concepts of firmware using ARM MBed kits), Field-Programmable Gate Array (FPGA) programming (XIlinx Spartan series), and practical hands-on experience in all the embedded programming languages covered above.
EE1193 2 Introduction to Hardware Description Languages	Overview of digital design workflow; Simulation of design - timing and delays, concurrency; Verilog basic constructs; Overview of FPGA toolchain (using ICOBoard); Structural and behavioural descriptions with several examples; I/O and memory interaction; Advanced examples.
EE1210 1 Basic Control Theory	Course Content: Applications of controllers and control systems, basic building blocks of a control system, types of controllers, thumb rules for designing P/PI/PD/PID controllers, advantages of control system, stability analysis, time response analysis, frequency response analysis, introduction to modeling, controller design and implementation using MATLAB/SCILAB.
EE1310 1 Signals and Communications	Introduction: The communication process, Sources of information, Communication channels, Baseband and pass band signals, Representation of signals and systems, The modulation process, Information theory and coding, Analog versus digital communications Representation of signals and systems: Notation of energy and power, Dirac delta function, Continuous-time LTI systems and their properties, The Fourier transform and its properties, Transmission of signals through linear systems, Filters, Hilbert transform, Pre-envelope, Canonical representation of band-pass signals, Phase and group delay. Modulation: Amplitude modulation, Double sideband-suppressed carrier modulation, Single sideband modulation, VSB, Frequency modulation, Phase-locked loop.
EE1320 1 Internet of Things	Introduction: Concept, Importance, Interdisciplinary, Challenges, Various applications smart objects, Major Players/Industry. Standards IoT Architecture: Node structure: Sensing, Processing, Communication Powering Networking: Topologies, Layer/Stack architecture Communication Technologies: Introduction to ZigBee, BLE, WiFi, LTE, IEEE 802.11ah, Discuss data rate, range, power, computations/bandwidth, QoS. Smartness - Signal Processing/Analytics: Impact on Power/Energy savings, dynamic networks, simple case studies. IoT Fabricator: Introduction to Embedded electronics, fabricating electronics, Communication Network requirements, Data processing challenges - recreation, IP/security, Challenges. Hands-on in IoT (Starts in the first week and goes on until end of course): Projects based on some Hardware (Raspberry pi, Arduino, Intel, IITH Mote, Smartphones), Software (Contiki, TinyOS, Android), IoT Fabricator
EE1350 1 Signals and Systems	Properties of Systems - linearity, time-invariance, causality and stability, Natural response of 1st order and 2nd order systems, Transfer functions and Convolution, Sinusoidal Steady State and Frequency response, Fourier Series and Fourier transform, Laplace transform, Circuit analysis through Laplace transform.
EE1360 1 Communication Systems	Physical layer description of communication systems, quantization, data formatting and framing, capacity of a point-to-point link, link budget analysis, multiple access techniques (fixed and random access), circuit and packet switching, network routing, reliable transport in data networks
EE1370 2 Data Analytics	Statistical modeling of large data sets, correlation and regression analysis, time series analysis, elementary hypothesis testing, framework for probabilistic abstraction of data, axiomatic definition of probability Combinatorics: Probability on finite sample spaces, Joint and conditional probabilities, independence, total probability; Bayes' rule and applications, Random variables, Definition of random variables, continuous and discrete random variables, cumulative distribution function (cdf) for discrete and continuous random variables; probability mass function (pmf); probability density functions (pdf) and properties, Jointly distributed random variables, conditional and joint density and distribution functions, independence; Bayes' rule for continuous and mixed random variables, Function of random a variable, pdf of the function of a random variable.
EE1390 1 Introduction to AI and ML	Classification and regression using linear and nonlinear models, Bayes decision theory, risk minimization, multilayer perceptron and support vector machines (SVM).
EE2010 2 Engineering Electromagnetics	Review of vector calculus, Static electric fields, Coulombs law, Gauss law, Electrostatic potential, Dielectrics and boundary conditions, Capacitance, Green's reciprocation theorem, Magnetostatics, Ampere's law, Magnetic vector potential, Self and mutual

inductance, Time varying fields, Electromagnetic induction, Maxwell's equations.

EE2110 **1**
Microprocessors
▷Applied Logic Design

Microcontrollers: 8085/8051
Assembly programming: Arithmetic operations, logical operations, interrupt handling, interfaces for microcontrollers, ADC and DAC interfaces for microcontrollers, application project. Reading Materials: Microprocessor Architecture, Programming and Applications with the 8085 6/e, Penram International Publishing, 2013.

EE2120 **1**
Device Physics

PN Junction: Space Charge region, Poisson's Equations, Static analysis, Energy Band Diagrams, Biasing, Small signal analysis, Breakdown mechanism. Bipolar Junction transistor: Injection Efficiency, Current base current gain, Common emitter current gain, AC analysis, Impact Ionization, Punch through. Transit time, Charge control description. Theory of Field Effect Transistors: Static characteristics of JFETs, heterojunction bipolar transistors, MOS Capacitor analysis, C-V measurements, Drain Current, Small signal analysis.

EE2133 **1**
Analog Electronics
▷EE1010, EE1020

Introduction to Analog Electronics and Application, Devices parameters: Analog perspective and significance, Macro-modelling: small signal and behavioral, Amplifiers: single stage and differential, Biasing: Voltage and current bias, Test board design

EE2134 **2**
Analog System Design

Application of operational amplifiers. Building blocks of operational amplifiers. Data converter architectures and circuits. ADC architectures, circuits. DAC architectures and circuits. Phase locked loop. Analog filters.

EE2140 **1**
CMOS Fabrication

Introduction to CMOS technology, Czochralski method, Thermal Oxidation, Lithography, Physical Deposition Techniques, Diffusion, Ion Implantation, Cleaning, Wet etching, Dry etching, Chemical Vapour deposition techniques, Complete CMOS process flow.

EE2150 **1**
Digital Electronics
▷EE1010, EE1020, Digital System

Introduction to Digital Electronics, Logic Families, MOS Devices parameters: digital perspective and significance, Switching Properties of MOSFET. Analysis and design: CMOS Inverters, CMOS Static, Combinational and Sequential logic Circuits, Transmission gate logic circuits, Test board design.

EE2160 **1**
Embedded Systems

An overview of the application areas. State charts for design. Overview of components of an embedded system with ARM architecture as an example (CPU, memory, buses, peripherals etc.), CPU internals. Hands on with a single board computer (LPC1768). Software issues: processes and their management, memory overview.

EE2170 **3**
Mixed Signal Electronics
▷EE1130, EE2150

Introduction to Mixed signal Electronics, Power supply, mixed signal filters, OPAMPs and application, Data converters, Oscillator and Phase locked loop, Test board design

EE2187 **1**
Semiconductor Fundamentals

Semiconductor materials - Types of solids, Space lattices, Atomic bonding, Impurities in solids Introduction to quantum theory of solids - Energy quanta, wave particle duality, uncertainty principle, Schrodinger wave equation, Electron in free space, infinite potential well and step potential, Finite potential barrier and tunnelling, Allowed and forbidden bands, Electrical conduction in solids, Density of states function, Fermi Dirac distribution Semiconductor in equilibrium - Distribution of electrons and holes, Dopant atoms, energy levels and statistics, Extrinsic semiconductor, Charge neutrality, Position of Fermi level, Degenerate and non-degenerate doping, Fermi Dirac integral, Boltzmann approximation Carrier transport - mobility, drift and diffusion, continuity equation, graded impurity distribution and induced electric field, Einstein relations

EE2188 **1**
Electronic Devices and Circuits
▷EE2187

Nonequilibrium excess carriers in semiconductors - carrier generation and recombination, continuity and time dependent diffusion equations, ambipolar transport, Quasi-Fermi levels PN Junctions - zero applied bias, built-in potential, electric field and space charge width, reverse bias and junction breakdown, junction capacitance, non-uniformly doped junctions, PN junction current, IV characteristics, temperature effects, minority carrier distribution, generation-recombination effects, small signal model, tunnel diode, Nanohub simulations of PN junction devices Schottky barrier diode, Band diagrams for Ohmic and rectifying contacts, Heterojunctions - materials and band diagrams Bipolar junction transistors - basic principles and modes of operation, Minority carrier distribution and non-ideal effects, Equivalent circuit models Optical devices - optical absorption, electron-hole pair generation rate, PN junction solar cell, conversion efficiency, heterojunction and amorphous silicon solar cells, PIN diode, avalanche photo diode, Photoluminescence and electroluminescence, luminescent efficiency, LEDs-internal quantum efficiency and external quantum efficiency, laser diodes

EE2189 **2**
Physics of MOS Transistors
▷EE2187, EE2188

MOSCAP Operation - energy band diagrams, depletion layer thickness, work function differences, surface charge, flatband and threshold voltages, Capacitance Voltage curve - Ideal and frequency effects, Nanohub exercises on MOSCAP operation*, high-k dielectric

		and their impact on CV Long Channel MOSFET - Structure, IV Characteristics - mathematical derivation, Transconductance, Substrate effect, CV of MOSFET Short Channel MOSFET - Constant-Field and generalized scaling , short channel effects - channel length modulation, velocity saturation and subthreshold leakage Introduction to transistors in 21st century* - CMOS logic gates, inverters, NAND and NOR gates, FinFETs, Technology limitations, SPICE and TCAD simulations
EE2210	**2**	Transformer: Ideal transformer, losses, equivalent circuit, open circuit test, short circuit test, polarity test, efficiency, voltage regulation, construction, transients, poly-phase transformer. D.C. Machine: Armature windings, principle of operation, methods of excitation, equivalent circuit, generator characteristics, motor characteristics.
Transformer and DC Machines		
EE2211	**2**	Exp. 1: OC, SC and load test on 1- Transformer; Exp. 2: Sumpner's (Back-to-Back) Test on single phase transformer; Exp. 3: Speed Control of a DC Shunt Motor by Armature voltage method (below base speed) and Field resistance method (above base speed); Exp. 4: Determination of voltage regulation of a synchronous machine using EMF method; Exp. 5: V and inverted V curves of an synchronous motor; Exp. 6: No load and blocked rotor test on a 3- Induction Motor; Exp. 7: Determination of the Critical Speed and Critical Resistance of a Self-Excited DC Shunt Generator; Exp. 8: To perform the load test on DC shunt generator.
Electrical Machines Lab		
EE2220	**1**	Three Phase Synchronous Machine: Armature winding, MMF distribution, rotating MMF, equivalent circuit, open circuit test, short circuit test, operation on an infinite bus, synchronous condenser. Three Phase Induction Machine: Principle of operation, equivalent circuit, torque-slip characteristic, noload test, blocked rotor test. Fractional Horsepower Electric Machines: Basics of Linear induction motor, stepping motor, single phase induction motor.
AC Machines		
EE2240	**2**	Course Content: Classical control systems, optimal control systems, nonlinear systems, adaptive control, fuzzy logic control, neural networks.
Control Systems		
EE2310	**1**	Function of two random variables; Random vectors; Vector-space representation of random variables; Elements of estimation theory; Bounds and approximations; Sequence of random variables; Central limit theorem and its significance; Random processes; Spectral representation of a real WSS process; Linear time-invariant system with a WSS process as an input; Examples of random processes
Random Processes		
EE2320	**1**	Passband representation, Baseband equivalent AWGN Channel, Data Modulation and Demodulation, Synthesis of the Modulated Waveform, Discrete Data Detection, The Additive White Gaussian Noise (AWGN) Channel, Signal-to-Noise Ratio (SNR) Maximization with a Matched Filter, Error Probability for the AWGN Channel, MAP and ML detection, BPSK, FSK, QPSK, MPSK, PAM, QAM, DPSK, GMSK.
Digital Modulation Techniques		
EE2330	**1**	Radiation mechanisms, Fundamental parameters, Radiation integrals and vector potentials, linear dipoles and loop antennas, Yagi-Uda, Broadband antennas: Logperiodic, Helix; Impedance matching, Aperture antennas, Micro-strip Antennas.
Antenna Design		
EE2340	**1**	Information, discrete memoryless source, entropy, mutual information, capacity, source and channel coding theorems, shannon's capacity formula, rate-distortion theorem, differential entropy.
Information Science		
EE2350	**1**	Sampling, continuous and discrete-time transforms, z-transforms, finite impulse response (FIR) and infinite impulse response (IIR) filter design, FFT algorithm.
DSP		
EE2370	**2**	Frequency Domain Analysis of LTI Systems, Implementation of FFT, algorithms, Filter Design: IIR and FIR filters, Multi-rate signal processing: sampling rate conversion.
Advanced DSP		
EE3010	**2**	Wave Equation, Uniform plane electromagnetic waves, Wave propagation in infinite media, Polarization, Wave reflection and refraction, Waves on transmission lines, waveguides, cavity resonators, Antennas.
Wave Propagation and Transmission Lines		
▷EE2010		
EE3013	**2**	Data types, loops, conditions, functions, arrays, pointers, linked lists and trees.
Data Structures		
EE3113	**2**	Overview; Design abstraction levels; MOSFET device SPICE model; transistor scaling, design rules; timing and power considerations in design CMOS Inverter - Static and dynamic response, threshold, noise margin; propagation delay, parasitic capacitance
Introduction to VLSI Design		

		estimation; static and dynamic power consumption; SPICE analysis; inverter layout Combinatorial logic design in CMOS; Ratioed logic; Pass transistor logic; Introduction to Dynamic CMOS design Designing sequential logic circuits; latches and registers - static and dynamic response; Pipelining; Clocking strategy Timing issues in digital circuits; Synchronous and asynchronous circuits; Introduction to clock synthesis and synchronization Designing arithmetic building blocks - Adder; Multiplier; Shifter; Other arithmetic operations; Power-speed trade-off in design Introduction to memory and array structures; Memory core and peripheral circuits; Programmable logic arrays Summary and outlook
EE3120	**2**	Models of computers; Recent Trends; Instruction sets (example ARM); Performance evaluations of processors; Pipelining and instruction level parallelism; Memory Hierarchy; Superscalars, vector, GPUs and accelerators for ML; Peripherals and Interrupts; Examples of significant processors.
Microprocessor and Computer Architecture		
EE3180	**1**	Overview of measurements and the defining characteristics of sensors; Types of sensors used in health care, medical devices, specially chemical/biosensors, medical imaging and wearables; Basic circuits for conditioning and calibration of sensors; Examples in medical/healthcare devices; Recent trends - compressed sensing, AI/ML.
Sensor Technology for Intelligent Healthcare Systems		
EE3210	**1**	Components and organization of a power system; operational issues; different operating states; power flow modeling and analysis; state estimation; pricing of different services; power grid frequency control mechanism.
Smart Grid		
EE3220	**2**	Architecture of a power system, Line parameter calculation, Performance analysis of an AC transmission line, Load flow analysis, Short circuit analysis, Stability analysis, Economic load dispatch, Introduction to the protection system.
Power System Practice		
EE3230	**1**	The basics of power electronic switches, introduction to AC - DC (uncontrolled), Non-isolated DC - DC converters and single phase Inverters.
Power Electronics		
EE3250	**2**	The basics of power electronic switches, introduction to AC – DC (uncontrolled), Non-isolated DC – DC converters and single phase Inverters
Power Electronics		
EE3260	**1**	Introduction to Renewable Energy, World wide scenario, Indian Scenario, Primary attributes of different renewable energy sources; Solar Thermal, Solar Photovoltaics, Wind energy, Bio Energy, Geo thermal energy, other renewable sources, integration of renewable energy to the grid.
Renewable Energy and Power Systems		
EE3320	**1**	Wireless signal propagation and channel models, performance of modulation schemes in fading channels, diversity techniques, multiple-antenna systems, inter-symbol interference and mitigation techniques, cellular communication systems
Wireless Communications		
EE4180	**1**	Overview of measurements and the defining characteristics of sensors; Types of sensors - displacement, motion, temperature, pressure, flow, light/imaging, touch, chemical and biological; Basic circuits for conditioning and calibration of sensors; Examples in medical/healthcare devices; Recent trends - compressed sensing, AI/ML
Sensor Technology for Intelligent Healthcare Systems		
EE5110	**3**	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.
Semiconductor Device Modeling		
EE5120	**3**	Environment for VLSI Technology : Clean room and safety requirements, Single crystal growth (Technique), Crystal defects, Wafer cleaning processes and wet chemical etching techniques; Impurity incorporation : Solid State diffusion modelling and technology; Ion Implantation modelling, technology and damage annealing; characterisation of Impurity profiles; Oxidation : Kinetics of Silicon dioxide growth both for thick, thin and ultrathin films; Oxidation technologies in VLSI and ULSI; Characterisation of oxide films; High k and low k dielectrics for ULSI; 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,
VLSI Technology		

		CMOS and Bipolar circuits; Advanced MOS technologies
EE5127 Analog IC Design	**2**	Review of CMOS Process Device Modelling, CMOS Amplifier Basics, Current and Voltage Sources, CMOS Operational Amplifiers, Noise in MOS Circuits, Data Conversion Circuits, Switched Capacitor Techniques, Continuous Time Filters, Clock Generation for Mixed Signal System ICs
EE5128 Analog IC Design Lab	**1**	See EE5127, Analog IC Design
EE5130 Analog IC Design	**3**	Review of CMOS Process Device Modelling, CMOS Amplifier Basics, Current and Voltage Sources, CMOS Operational Amplifiers, Noise in MOS Circuits, Data Conversion Circuits, Switched Capacitor Techniques, Continuous Time Filters, Clock Generation for Mixed Signal System ICs
EE5139 Power Management Integrated Circuit Design	**2**	Part-1: Introduction to PMIC, Motivation, Linear Regulators, Switching Regulators. Part-2: Different analog linear regulator architectures, analysis, design, layout. Digitally controlled regulator architectures, analysis, design, layout and testing. Part-3: Different switching regulator architectures (Current mode, Voltage mode, and Hysteretic, analysis, design, layout. Part-4: MIMO regulators, battery chargers. Part-5: Design of pA load DC-DC converters.
EE5140 Digital IC Design	**3**	Basic of Digital Design: Introduction to digital system, Synchronous and asynchronous system design, Finite State Machine with case studies, ASIC Design: Introduction to RTL (HDL) coding, Test bench writing, Combinational and Sequential circuit using HDL with examples., Methodology for Digital Design: Synthesis, Timing analysis and verification, Introduction to Physical design, Computer Arithmetic for data path design: Fast adders, multipliers, dividers. CORDIC, Basic of DSP and Digital Communication systems architecture.
EE5147 Digital IC Design	**2**	Basic of Digital Design: Introduction to digital system, Synchronous and asynchronous system design, Finite State Machine with case studies, ASIC Design: Introduction to RTL (HDL) coding, Test bench writing, Combinational and Sequential circuit using HDL with examples., Methodology for Digital Design: Synthesis, Timing analysis and verification, Introduction to Physical design, Computer Arithmetic for data path design: Fast adders, multipliers, dividers. CORDIC, Basic of DSP and Digital Communication systems architecture.
EE5148 Digital IC Design Lab	**1**	See EE5147, Digital IC Design
EE5155 Semiconductor Optoelectronics ▷EE1140, EE2180, Elementary Quantum Mechanics	**1**	Basic semiconductor properties, semiconductor materials - heterojunctions, quantum wells, quantum dots, optical processes in semiconductors, selection rules, fundamentals of LEDs, semiconductor diode lasers, single/multijunction solar cells and photodetectors.
EE5167 Embedded System Hardware and Design	**2**	Processors: ISA, Pipelining and Hazards, Optimisations. RISC-V and ARM architectures. Memory: Hierarchy, Cache, Virtual Memory. System and peripheral buses. AMBA and AXI. Peripherals: I/O, Interrupts, JTAG. Sensors: characteristics, useful circuits, PID control basics. Operating Systems: RTOSes, Monolithic and Microkernels. Task scheduling: algorithms and resource sharing.
EE5168 Embedded Systems: Hardware Languages	**1**	Overview of Verilog. Overview of PICORV32. Implementation of simple custom extensions and co-processors.
EE5170 Thin-film Transistors	**3**	• Device physics for thin-film transistors • Thin film transistors structures and performance • Poly-Si TFTs: Technology, performance, and architecture • Amorphous Si-TFTs: technology, performance, and architecture • Organic TFTs: Materials, fabrication, architecture, performance, and instability factors. • Amorphous metal oxide TFTs: Materials, fabrication processes, characteristics, architecture and performance. • TFTs on flexible substrates.
EE5191 Digital Holography	**1**	Wave optics, scalar diffraction theory, Fresnel and Fraunhofer diffraction, types of holograms, numerical reconstruction, recording of digital holograms with image sensors, applications of digital holography in microscopy.

EE5200 **3**
Steady State Power System

Steady- state Modeling of the Power Network: Understanding the basic architecture of a transmission network, three-phase modeling of the different elements of a transmission network, formation of three-phase impedance and admittance matrices, review of the theory of sequence transformation, equivalent single-phase representation of the transmission network. Performance Analysis of an AC Transmission Line: Voltage and current profiles over a transmission line, loadability, shunt compensation, series compensation. Power System Load Flow Analysis: Numerical methods for solving non-linear algebraic equations, reference concepts in the context of power flow analysis, load modeling, lumped slack power flow analysis,
distributed slack power flow analysis, linearized representation of system's loss characteristics, DC power flow analysis, loss-compensated DC power flow analysis and the concept of power flow accuracy, three-phase load flow analysis, introduction to the optimal power flow analysis. Unit Commitment: Principle of unit commitment, constraining factors of unit commitment, a brief overview of different methods for solving unit commitment problem. Power System Short Circuit Analysis: Thevenin's equivalent of the power network, balanced short circuit analysis, unbalanced short circuit analysis. Power System State Estimation: Review of basic statistics, philosophy of state estimation, least square based method for power system state estimation, constrained state estimation, bad data detection, introduction to network observability analysis, introduction to network topology processor. Modeling and Analysis of Distribution Network: Understanding the basic architecture of a distribution network, modeling of the different components of a distribution network, distribution system power flow analysis, distribution system fault analysis.

EE5207 **1**
Steady State Modelling of Power Systems

Modeling of synchronous generators, transformer modeling, transmission line modeling, modeling of shunt elements, load modeling, modeling of single phase and three phase power systems, symmetrical components

EE5210 **3**
Power Converter Design

Characteristics of power electronic switches, Drive circuits, AC to DC rectifiers (single phase/three phase), analysis and performance with passive loads, Basics of DC-DC converters, Basic principles of cycloconverter (AC to AC Conversions) operation, DC/AC inverters (single phase and three phases) and PWM Control techniques.

EE5217 **2**
Computer Aided Power System Analysis

Numerical methods for solving system of nonlinear equations, Single phase and three phase power flow analysis, short circuit analysis, Analysis of distribution systems

EE5220 **3**
Advanced Control Systems

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.

EE5221 **2**
Advanced Control Lab

Design and implementation of advanced control strategies on experimental systems: i) Twin Rotor MIMO system, ii) 2dof robotic manipulator, iii) Ball balancer system.

EE5227 **1**
Basics of Power Electronic Converters

Characteristics of power electronic switches, Drive circuits, AC to DC rectifiers (single phase/three phase), analysis and performance with passive loads, Basics of DC-DC

EE5230 **3**
Power System Dynamics and Control

A brief introduction to nonlinear dynamics, Numerical methods for solving differential equation, dynamic modeling of power system components, simulation of power system dynamics, power system stabilizer design, direct methods for transient stability assessment, sub-synchronous resonance, introduction to voltage stability, introduction to electro-magnetic transient simulation

EE5237 **2**
Analysis and Design of Power Electronic Converters

Characteristics of power electronic switches, Drive circuits, AC to DC rectifiers (single phase/three phase), analysis and performance with passive loads, Basics of DC-DC converters, Basic principles of cycloconverter (AC to AC Conversions) operation, DC/AC inverters (single phase and three phases) and PWM Control techniques.

EE5240 **3**
Electrical Machines and

Basic principles of electric machines, magnetically coupled circuits, machine windings and air-gap MMF, Winding inductances and voltage equations, DC machines - Theory of

Analysis Control	DC machines, voltage and torque equation (DC Machine) in machine variables and Block diagrams . Reference Frame theory - equations of transformation, commonly used reference frames, transformation between reference frames, transformation of a balanced set. Induction machine Voltage and torque equation in machine variables, arbitrary reference frame equivalent circuits, voltage and torque equations in arbitrary reference frame variables, dynamic performance of induction motor, Vector control of induction motor. Synchronous machine - Voltage and torque equations in machine variables, equivalent circuits of 3-phase synchronous machine in arbitrary reference frames.
EE5247 2 Dynamics of Power System Components	State-space modeling of a dynamical system, equilibrium analysis, d-q transformation, generator dynamics, excitation control system, speed control system, load dynamic, network dynamics, OLTC dynamics
EE5257 1 Power System Stability Analysis	Simulation of power system dynamics, model reduction, classification of power system instability phenomena, power system stabilizer design, overview of energy function method for the transient stability assessment, introduction to the SSR problem
EE5267 1 Analysis of DC Machines and Reference Frame Theory	Basic principles of electric machines, magnetically coupled circuits, machine windings and air-gap MMF, Winding inductances and voltage equations, DC machines - Theory of DC machines, voltage and torque equation (DC Machine) in machine variables and Block diagrams . Reference Frame theory - equations of transformation, commonly used reference frames, transformation between reference frames, transformation of a balanced set. Induction machine Voltage and torque equation in machine variables, arbitrary reference frame equivalent circuits, voltage and torque equations in arbitrary reference frame variables, dynamic performance of induction motor, Vector control of induction motor. Synchronous machine - Voltage and torque equations in machine variables, equivalent circuits of 3-phase synchronous machine in arbitrary reference frames.
EE5277 2 Analysis of AC Machines	Basic principles of electric machines, magnetically coupled circuits, machine windings and air-gap MMF, Winding inductances and voltage equations, DC machines - Theory of DC machines, voltage and torque equation (DC Machine) in machine variables and Block diagrams . Reference Frame theory - equations of transformation, commonly used reference frames, transformation between reference frames, transformation of a balanced set. Induction machine Voltage and torque equation in machine variables, arbitrary reference frame equivalent circuits, voltage and torque equations in arbitrary reference frame variables, dynamic performance of induction motor, Vector control of induction motor. Synchronous machine - Voltage and torque equations in machine variables, equivalent circuits of 3-phase synchronous machine in arbitrary reference frames.
EE5287 1 Basics of Power System Protection	Various scientific disciplines requiring image analysis: medical fields including ophthalmology and radiology, surveillance and navigation, biological sciences including live cell/tissue dynamics, and so on; unique image analysis challenges arising in various fields; basic image analysis tools such as histogram, contrast enhancement, edge and other feature detection, elementary segmentation, wavelet analysis, basic morphological processing; strategies towards tackling practical challenges: case studies.
EE5297 2 Advanced Power System Protection	Numerical Relaying: An Introduction, Sampling Theorem, Algorithms for Phasor Estimation-II; Current and Voltage Transformers: Introduction to CT, CT Saturation and DC Offset current, Introduction to VT, performance issues of current and voltage transformers Digital protection schemes for transmission lines, generators, and transformers: Overcurrent protection, Directional overcurrent protection, Distance protection, Differential protection, Out-of-Step protection. Additional topics of protection: Adaptive relaying, integrated substation protection and control, new relaying principles based on AI techniques, ANN approach and Fuzzy logic (FL) methods for fault detection and fault location, wide area monitoring, protection and control systems
EE5300 3 Digital Signal Processing	Review of LTI systems and their properties, Convolution sum, Sampling of continuous-time signals, Discrete-time Fourier transform (DTFT) and its properties, Sampling in frequency domain, Discrete Fourier transform (DFT) and its properties, Z-transform and its inverse, region of convergence, pole-zero locations and frequency response, stability analysis, implementation of discrete-time systems, design of FIR filters and IIR filters, linear phase filters, group delay, response of first and second order filters, Computational issues in DFT, FFT algorithm, Applications of DSP.
EE5307 1 Complex Analysis in Electrical Engineering	Properties of Analytic functions, Cauchy's integral formula, applications in Fourier, Laplace, Z transforms and probability theory.

EE5310 **3**
Probability and Random Processes

Introduction to Probability; Definitions, scope and history; limitation of classical and relative-frequency-based definitions, Sets, fields, sample space and events; axiomatic definition of probability , Combinatorics: Probability on finite sample spaces, Joint and conditional probabilities, independence, total probability; Bayes' rule and applications, Random variables, Definition of random variables, continuous and discrete random variables, cumulative distribution function (cdf) for discrete and continuous random variables; probability mass function (pmf); probability density functions (pdf) and properties, Jointly distributed random variables, conditional and joint density and distribution functions, independence; Bayes' rule for continuous and mixed random variables, Function of random a variable, pdf of the function of a random variable; Function of two random variables; Sum of two independent random variables, Expectation: mean, variance and moments of a random variable, Joint moments, conditional expectation; covariance and correlation; independent, uncorrelated and orthogonal random variables, Random vector: mean vector, covariance matrix and properties, Some special distributions: Uniform, Gaussian and Rayleigh distributions; Binomial, and Poisson distributions; Multivariate Gaussian distribution, Vector-space representation of random variables, linear independence, inner product, Schwarz Inequality, Elements of estimation theory: linear minimum mean-square error and orthogonality principle in estimation, Moment-generating and characteristic functions and their applications, Bounds and approximations: Chebysev inequality and Chernoff Bound, Sequence of random variables and convergence, Almost sure (a.s.) convergence and strong law of large numbers; convergence in mean square sense with examples from parameter estimation; convergence in probability with examples; convergence in distribution, Central limit theorem and its significance, Random process: realizations, sample paths, discrete and continuous time processes, examples, Probabilistic structure of a random process; mean, autocorrelation and autocovariance functions, Stationarity: strict-sense stationary (SSS) and wide-sense stationary (WSS) processes, Autocorrelation function of a real WSS process and its properties, cross-correlation function, Ergodicity and its importance, Spectral representation of a real WSS process: power spectral density, properties of power spectral density ; cross-power spectral density and properties; auto-correlation function and power spectral density of a WSS random sequence, Linear time-invariant system with a WSS process as an input: sationarity of the output, auto-correlation and power-spectral density of the output; examples with white-noise as input; linear shift-invariant discrete-time system with a WSS sequence as input, Spectral factorization theorem, Examples of random processes: white noise process and white noise sequence; Gaussian process; Poisson process, Markov Process.

EE5317 **1**
Optimization

Convex functions, Linear Programming, Semi-Definite Programming, Karush–Kuhn–Tucker conditions, Solvers, Applications in Research.

EE5320 **3**
Digital Communications

Basebad Digital Transmission:PAM, PWM, PPM,PCM,DM. Digital Transmission: BPSK, QPSK, QAM, BER Analysis, Performance in Rayleigh, Rician and Nakagami Fading

EE5328 **1**
Introduction to Submodular Functions

Definition, examples and properties; modeling discrete optimization problems using submodular functions; Lovasz extension and minimization, discrete and randomized algorithms for maximization; selected applications among machine learning (active/semi supervised learning, feature selection, regularization using structured sparsity, clustering), inference and learning for graphical models, circuit design and network analysis, social networks and computer vision.

EE5330 **3**
Information Theory and Coding

Measures of information: Entropy, mutual information, differential entropy, Kullback Leibler distance, role of convexity, information inequalities, Source coding without loss: prefix codes, Kraft's inequality, Shannon, Huffman, arithmetic coding, Channel coding: Hamming codes, concept of Reed Solomon codes, convolution codes, turbo codes and LDPC codes, Method of types: universal source coding, Lempel-Ziv Coding, Lossy source coding: rate distortion theory via type-covering, Rate-distortion functions for the binary hamming and the Gaussian, mean-squared error problems, Channel coding: Shannon capacity via sphere-packing, Capacity of binary symmetric and Gaussian channels, Rate allocation in Gaussian source and channel coding: Reverse waterfilling and waterfilling, Application to signal compression and wireless communication.

EE5340 **3**
Detection and Estimation

Elements of hypothesis testing: Bayesian, minimax, Neyman-Pearson, composite; Gaussian hypothesis testing; Discrete-time signal detection: models and detector structures, performance evaluation - direct computation, Chernoff and related (large-deviation) bounds, asymptotic relative efficiency, sequential detection, nonparametric and robust detection; Parameter estimation: Bayesian, nonrandom,

		maximum likelihood; Signal estimation: Kalman-Bucy filtering, linear estimation, Wiener-Kolmogorov filtering; Continuous-time signal detection: Grenander's theorem and Karhunen-Loéve expansion, detection of deterministic signals in Gaussian noise, detection of random signals in Gaussian noise, estimator-correlator representation; Continuous-time signal estimation: Linear innovation process, continuous-time Kalman-Bucy filter, Optimum nonlinear filtering, practical approximations; Application to communication systems: DSB-AM, DSB-SC, SSB-SC.
EE5342	**1**	Binary Detection Rule single observation, Maximum likelihood, Neyman-Pearson, Minimum Probability of Error, Bayes Risk, Min-max, Multiple observations, M-ary Detection rule, Composite and non-Parametric detection Theory
Detection Theory		
EE5343	**1**	Fundamentals of Estimation, Maximum likelihood, Bayes Cost, Relationship of Estimators, Linear minimum variance and Least Squares, Estimation with Gaussian Noise, Properties of Estimators, State Estimation, Kalman Filter.
Estimation Theory		
EE5350	**3**	This course deals with the design, structure and decoding of Linear Block Codes, G Fields, Cyclic Codes, BCH, Convolution Codes, TCM, TURBO and LDPC codes.
Error Correcting Codes		
EE5360	**3**	Various scientific disciplines requiring image analysis: medical fields including ophthalmology and radiology, surveillance and navigation, biological sciences including live cell/tissue dynamics, and so on; unique image analysis challenges arising in various fields; basic image analysis tools such as histogram, contrast enhancement, edge and other feature detection, elementary segmentation, wavelet analysis, basic morphological processing; strategies towards tackling practical challenges: case studies.
Practical Challenges in Image Analysis		
EE5366	**1**	Introduction to Wireless Systems. (0.5 hours), Wireless Channel Model, Review principles of digital communications, Single user point-to-point fading channel detection, Multi-access schemes, Capacity of point-to-point Wireless Channels.
Fundamentals Wireless Communications		
EE5368	**2**	ISI and need for equalization in wireless channels, Review of capacity of point-to-point channels, Coding for Wireless channels, Adaptive Modulation and coding
Advanced Wireless Communications		
EE5370	**1**	Unsupervised learning - clustering, latent variable models, supervised learning - classification, regression, multilayer perceptrons
Introduction to Machine Learning		
EE5410	**3**	Why Nonlinear Control?; Phase plane analysis; Fundamentals of Lyapunov Theory; Advanced stability theory; Describing Function analysis; Feedback Linearization; Sliding Control; Adaptive control
Nonlinear Control Theory		
EE5440	**1**	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
Classical Control Techniques for Mimo Systems		
EE5450	**2**	Introduction to advanced control approaches, 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.
State Feedback Control		
EE5460	**2**	Why Nonlinear Control?; Phase plane analysis; Fundamentals of Lyapunov Theory; Advanced stability theory; Describing Function analysis; Input-output stability; Notion of passivity;
Analysis of Nonlinear Systems		
EE5470	**1**	Feedback Linearization;
Nonlinear Control Techniques		
EE5480	**1**	Pontryagin's Principle; Linear Quadratic Regulator; Time Optimal Control; Fuel Optimal Control
Optimal Control		
EE5490	**2**	Why robust control? What is robust control: Problem definition; Youla parameterization; H-infinity control.
Robust Control Techniques		

EE5600 Introduction to AI and ML	**1**	Classification and regression using linear and nonlinear models, Bayes decision theory, risk minimization, multilayer perceptron and support vector machines (SVM).
EE5601 Representation Learning	**1**	Clustering and latent variable models, auto-encoders, energy based models, manifold learning, and deep networks.
EE5602 Probabilistic Graphical Models	**1**	Bayesian networks, undirected graphical models and their temporal extensions, exact and approximate inference methods, parameter estimation.
EE5603 Concentration Inequalities	**1**	Markov inequality, Chebyshev inequality, Jensen's inequality, Han's inequality, Hoeffding's inequality, Bernstein's inequality, Stein's inequality
EE5604 Introduction to Statistical Learning Theory	**1**	Consistency, uniform laws of large numbers, VC dimension, entropy integrals, Rademacher complexity, statistical consequences
EE5605 Kernel Methods	**1**	Reproducing kernel Hilbert spaces (RKHS), Fourier properties and analysis, randomized and low-rank approximations
EE5606 Convex Optimisation	**2**	Convex sets and functions (definitions, operations preserving convexity, separating and supporting hyperplane theorems, Jensen's inequality, epigraphs, quasi convexity and other properties), convex optimisation (subtypes: LP, QP, QCQP, SOCP, SDP, Geometric programs: definitions and properties; transformation techniques; using CVX), KKT conditions and duality, interpretation of dual variables, gradient descent, convex relaxation and examples.
EE5607 ML – Hardware Implementation	**1**	0. Overview of the ML Hardware implementation 1. ML Hardware on FPGA - theory, and practice 2. High-Level Synthesis - will help non-VLSI guys to get the RTL using theseapproaches. 3. Hardware-software co-design 4. ChaiDNN demo - practical approach: Here people will learn how to dump their codes from Caffe platform to the FPGA boards. They will have the prerequisite of hw-sw co-design already by that time. Here, theflow from caffe to ChaiDNN will be demonstrated by considering a small example and demonstrate the outcomes, resource consumption etc.. This session may last for 1- 1.5 hours. It will be followed by a Practical Session. This may take another 1.5 hours. So total duration of this session will be tentatively 3 hours. 5. Network On Chip and GPU based designs of ML Hardware- Duration will be tentatively for 3 hours. First 1.5 to 2 hours on NOC and rest on GPU. This may include the state of the ML hardware - literature review and their brief description. Bit of research insights will also be provided 6. Case Studies – Indigenously designed and developed hardware designs of our recently proposed Rehab-NET, Amputee-NET and RIM-NET: Rehab-NET - Its hardware implementation using the Modified Distributed Arithmetic (MDA) approach will be presented. Reference: Our IEEE ECCTD paper. Amputee-NET - Its hardware design will be presented with a bit of description of the algorithm and its novelty. RIM-NET – Its GPU (Jetson TX2) based implementation will be presented and novelty will be explained. 7. DNN and Hardware Compression technique for the Deep Net
EE5608 Sequence Modelling	**1**	Markov models, Hidden Markov models, Kalman filters, Linear Dynamical Systems, Recurrent and Recursive Neural Networks (RNNs), LSTMs, BLSTMs, Sequence-to-Sequence learning
EE5609 Matrix Theory	**3**	1. Modeling using matrices: Basic examples, graph theory (adjacency/Laplacian), probability and statistics (Covariance matrices, Markov matrices), signal processing (Fourier matrices, convolution/filtering), communication (Linear codes, MIMO, STBC), machine learning (clustering, dimensionality reduction), basic linear dynamical systems etc 2. Row/column spaces and rank, basic matrix operations (multiplication, transpose, determinant, trace, inverse, etc), matrix types, rank-nullity, underdetermined/overdetermined systems of linear equations, block matrices 3. Matrix decompositions - eigenvalues, SVD and applications like PCA, LU and Cholesky decomposition, QR and Schur decomposition, non-negative matrix factorization, Quadratic forms 4. More on determinants - its algebraic properties, how to compute determinants 5. Characteristic polynomial and its properties 6. Solving Ax=b, least

squares and its many variants, min norm solutions for underdetermined systems of linear equations, other optimization problems framed using matrices; pseudo inverse, matrix norms 7. Special matrices: Toeplitz, Circulant, Fourier etc. 8. Generalized eigenvectors and Jordan form 9. Solutions to systems of ordinary differential equations, matrix exponent 10. Numerical issues and common matrix algorithms, linear algebra in MATLAB/python 11. Intro to random matrices and context in which they are useful.

EE5611 2
Machine Learning Applications for Wireless Communications
▷EE5600, EE5320 or EE3320, EE6337 or equivalent

Introduction to Machine Learning, Supervised, Unsupervised learning, Online learning techniques including Reinforcement learning techniques such as Q-Learning, Post Decision State Learning, Markov Decision Processes, Multi-armed bandits and Deep Learning techniques. Applications in various wireless communications problems and design of enhanced wireless communications systems and mobile networks using the above tools. Each class includes an introduction to a certain type of tools, and is followed by introducing various problems in wireless communications/ networks and how those tools can be used for the same. The students have to work on a project using a tool of their choice and solve a relevant problem or implement a relevant recent paper where ML is used to solve a wireless communications problem.

EE5817 2
Random Variables

Review of probability, introduction to random variables; pmf, pdf and cdf; Mean, variance and moments; Markov and Chebyshev inequalities, Chernoff bounds; convergence of random variables, weak law of large numbers and the central limit theorem; Introduction to estimation, MMSE and LMMSE.

EE5827 1
Random Processes

Random processes, mean and autocorrelation, Stationarity and ergodicity, Filtering random processes; Markov chains, transience and recurrence; Poisson point processes; examples and applications.

EE5848 2
Topics in Information Theory and Coding
▷EE2340 or EE5847, recommended EE5350 and EE6317

Review MDS codes and relation to polynomials. Introduction to straggler mitigation using coded computation. Reducing communication bandwidth through coded data shuffling. Distributed matrix multiplication using entangled polynomial codes, PolyDot codes, MatDot codes and product codes. Lagrange coded computing for robustness, privacy and secrecy. Coded gradient descent using fractional repetition codes, MDS codes, expander graphs and overcomplete representations. Coding for approximate gradient descent. Coded Fourier transform.

EE6010 2
Applied Algebra

This is a basic subject on matrix theory and (linear) algebra. Topics to be covered include, groups, systems of equations, vector spaces, determinants, eigenvalues, similarity, and positive definite matrices, linear transformations, symmetry groups, bilinear forms, and linear groups.

EE6120 3
Nanoelectronics: Principles and Devices

Introduction to the principles of quantum mechanics, quantum operators, wave-particle duality, wavefunctions and Schrödinger's equation; Quantum-mechanical origin of the electrical and optical properties of materials and nanostructures, absorption, luminescence, transport including tunneling in low-dimensional semiconductors, transport in nanoMOSFET, velocity saturation; ballistic transport, single-electron devices, calculation methods, thermal transport in nanostructures, emerging nanomaterials and structures including graphene, graphene nanoribbons, carbon nanotubes; properties and applications in electronics, photonics, bioelectronics, energy harvesting.
Nanostructure devices- Introduction, Resonant-tunneling diodes, Field-effect transistors, Single-electron-transfer devices, Potential-effect transistors, Light-emitting diodes and lasers, Nano-electromechanical system devices, Quantum-dot cellular automata.

EE6140 3
Introduction to Biosensor Technology

Silicon microfabrication, Cantilever biosensors, Surface Micromachining, Bulk Micromaching, Soft lithography, Nano Imprint Lithography, Dip-Pen lithography, Application of Nanotechnology for surface modification, Self Assembled Monolayers, Polyelectrolyte multilayers, Functionalization of Carbon Nano tubes, Electrochemical sensors, chronoamperometry, cyclic voltammetry, differential pulse voltammetry, Electrochemical Impedance spectroscopy, Optical Sensors, colorimetry, fluorescence, Surface Plasmon Resonance, Immunoassay detection, antibody-antigen interactions, lateral flow immunoassay, integrated lab on chip devices, Enzyme linked immunosorbent assay (ELISA).

EE6150 3
Nanophotonics and Metamaterials
▷Fundamentals of Classical Electrodynamics, Device Physics and Vector Calculus

1. Light-matter interaction 2. Introduction to Photonic Crystals 3. Plasmonics and Metamaterials 4. Silicon Photonics 5. Nanofabrication of optical meta-devices 6. Application of meta-devices in imaging, information processing, sensing, medicine and energy

EE6160 2

Boltzmann transport, semi-classical diffusive transport, Quasi-ballistic and ballistic

Mesoscopic Carrier Transport
▷EE5107, EE5117

carrier transport physics in nano-scale electronic devices, Non- equilibrium carrier transport, Quantum transport formalisms, Quantum coherence processes, Quantum corrections to charge electrostatics, Quantum conductance, Landauer transport, Wigner function formalism.

EE6170 3
Mesoscopic Device Electronics

Introduction to Mesoscopic Systems, Quantization of observables and reduced dimensionality of electronic states, Mesoscopic physics of nano-scale MOSFETs, Carrier transport in mesoscopic systems, Conductance viewed as transmission and conductance channels, Ballistic and quasi-ballistic transport, Carrier transport in nanowires, Quantum dots and coulomb blockade, Quantum well and super-lattices, Resonant tunneling Diodes, Quantum Hall effect, Superconducting electronics, and Graphene physics.

EE6180 3
Biomedical IC Design

Part 1: BIOSIGNAL-SENSING: Technology and Design Perspective: Introduction to Bio-Sensing and Bio-Sensors:- focusing on what is bio-sensing, why is it necessary, what are different bio-sensors, how to design these, what are the state-of-the art techniques, what is the future, and then link it to the chapters under this part. Biosensor fabrication technology:- The objective is to give a thorough understanding of basic fabrication technologies for making sensors and surface modification and detection methodologies which enables the use of these sensors for selective biomolecule detection. Surface modification methodologies and Characterization techniques:- The objective is to give a thorough understanding of characterization techniques necessary to develop biosensors, modification methodologies which help in preconcentration, isolation, amplification of bioanalyte of interest and methods to eliminate interferences. Detection methodologies:-Electrochemical detection, Immunoassay detection, Bio-Photonics and Optical detection, Micro Analytical Systems, Biopotential measurements. Miniaturized instruments for biosensors:- Potentiostat, Galvanostat, Measuring electronics based on off the shelf components; Reflectance measurements, Fluorescence microscopy, Handheld instrumentation.
Part-2: BIOSIGNAL-PROCESSING: AlgorithmS and IC Design Perspective: Introduction :-Role of Signal processing in healthcare-Case studies (1. Foetal ECG separation from maternal ECG, 2. ECG feature extraction, 3. EEG analysis); Different types of signal processing techniques, Remote healthcare: technology driven next-generation healthcare: Need of remote healthcare, Overview of remote healthcare architecture; Role of Technology Signal processing for remote healthcare: Potential Challenges. Fundamentals of biomedical signal processing: signal pre-processing, denoising, artifact separation, filtering signal compression-decompression:- Overview of Biomedical signal processing techniques; Detailed discussion with various case-studies on the real life problems. Constraints for applying traditional signal processing techniques in remote healthcare - low-energy issue:- Traditional Signal Processing algorithms vs. Practical Constraints; Need of an holistic view of Algorithm and VLSI Architecture; Technology for next generation bio-medical signal processing. Arithmetic complexity and trade-off analysis for biomedical signal processing processes:- Hardware complexity analysis of resource constrained system; Computational Delay analysis of resource constrained system; Trade-off analysis : Arithmetic complexity vs Signal parameters.
Part-3: BIOSIGNAL-COMMUNICATION: Practical Design Perspective: Wireless Sensor Networks for Healthcare:-Overview of wireless sensor networks, Network characteristics, Network Design and Challenges, Some applications and WSN requirements for specific applications. Wireless Sensor Network Protocol Stack, algorithms and design:- Wireless Sensor Protocol Stack, Physical Layer, Medium Access Control, Network Layer, Transport and Application Layer, Cross Layer. Data Aggregation and some Advanced Topics:- Sensor Data aggregation techniques, Sensor Data storage, Data Management and Processing; Time Synchronisation in WSN: Need and Techniques; Sensor Node localisation: Need and Techniques; Security and Privacy - Authentication and Cryptography; Wireless Sensor and Actuator Networks - Bidirectional Network design, Control on Sensor Networks - design challenges and solutions. Healthcare on Mobile Platforms:-Need for mobile platforms for healthcare applications; Mobile application development for Healthcare: Wireless Sensor Data collection (Bluetooth, WiFi, 3G..), Data Processing and Alert generation; Some examples on Android Application development for mobile platforms.

EE6197 1
Digital Chip Design for Futuristic Cardio-vascular Health monitoring

Cardio Vascular Disease overview, current status, challenges and future directions including 2 European funded long-term research Projects: CHIRON and HEARTMAN and how these can be viewed from a Medico- engineering perspective, Next generation Technology requirement in remote CVD monitoring, Low power hardware design for CVD monitoring, Diagnostic Features and their effects on human health, Importance of ICT for patients with Hypertrophy, Heart Failure and other major heart related diseases. Areas of interest to improve patient reported outcomes in CHF patients: physical activity,

		medication and nutrition; Hardware and softwares needed for up-to-date telemedicine in CHF, IOT based technology platform design for remote healthcare, Importance of real time fragmentations detection from the ECG and On-chip Signal processing for detection of fragmentation, Bridging the gap between medical science and technology with Demo and hands on.
EE6201 Power System Lab	**2**	Introduction to sparse matrix computation, introduction to optimization in GAMS, introduction to steady-state analysis in PSS/E, introduction to transient analysis in PSCAD.
EE6210 Switched Mode Power Conversion	**1**	Linear dc to dc Power Converters, Non-idealities in Reactive Elements, Design of Inductors, Design of Transformers, Operating Principle of Non-isolated dc to dc Power Converters (buck, boost, buck-boost, Cuk) Equivalent Circuit Model of the non-isolated dc-dc converters. State Space Averaged Model of dc-dc Converters. Isolated converters (Forward, Flyback, Half/Full Bridge Converters). Closed Loop Control of Switching Converters, Resonant converters, zero current switching (ZCS) and zero voltage switching (ZVS).
EE6211 Power Electronics Lab	**2**	None
EE6220 Hvdc and Facts Applications	**3**	HVDC transmission: Principle of operation of HVDC transmission, components and structure of an HVDC link, transformer organization, basic control characteristics, ac-dc load flow analysis, multi-terminal HVDC transmission. FACTS devices: Operating principles and basic control characteristics of SVC, STATCOM, TCSC, UPFC and SPST. HVDC and FACTS applications: Control circuit design, small signal stability improvement, transient stability improvement, voltage stability improvement, power quality improvement.
EE6230 Electrical Drivers and Control	**3**	Introduction, Electrical Machines, Power Converters, Controllers, Modeling of DC Machines, State space modeling, Electro-mechanical model Phase controlled DC motor drives: Steady state analysis of the three phase converter controlled dc motor drive, two-quadrant, three phase converter controlled Dc motor drive, field weakening, four-quardrant dc motor drive, converter selection and characteristics, simulation Chopper controlled dc motor drive Polyphase induction motor drives: steady state equivalent circuit, dynamic modeling and simulation, slip energy recovery scheme, speed control of inductor motor Vector-controlled induction motor drives: principles of vector control, direct vector control, indirect vector control scheme, tuning of vector controller.
EE6240 Power System Protection	**3**	Introduction to power system protection (Evolution in protection systems, introduction to computer relaying, software tools for digital simulation of relaying signals, apparatus protection, system protection, desirable attributes of protection); Sequence Components and Fault Analysis (Sequence components, sequence modeling of power apparatus); Numerical Relaying (Signal conditioning, sampling and analog to digital conversion, real-time considerations, hardware design concepts - microcontroller/DSP based, single/multiprocessor based, relaying algorithms, software considerations); Current and Voltage Transformers (Introduction to CT, CT Saturation and DC Offset current, Introduction to VT, performance issues of current and voltage transformers); Digital protection schemes for transmission lines, generators, and transformers (Overcurrent protection, Directional overcurrent protection, Distance protection, Differential protection, Out-of-Step protection); Additional topics of protection (Adaptive relaying, integrated substation protection and control, new relaying principles based on AI techniques, ANN approach and Fuzzy logic (FL) methods for fault detection and fault location, wide area monitoring, protection and control systems)
EE6247 Introduction to Smart Grids	**1**	Introduction to Smart Grid, Smart Grid Conceptual Overview, Interoperability in power sector, Architectures for Smart Grids, Standards, Smart Tranmission System, Smart Distribution System, Smart Prosumer, Distributed Generation.
EE6257 Smart Grid Design and Implementation Aspects	**2**	Cost Benefit Analysis of Smart Grid Projects, Regulatory and Policy Issues, Indian Scenario, Information and Communication Technologies for Smart Grid, Demand Response, Smart Grid as foundation for Smart Cities, Smart Grid Design and Implementation Aspects, Student Projects on Smart Grids
EE6260 Control of Power Converters ▷Basic Power Electronics	**2**	Course contents: 1. Review of Modelling procedures of the power converters 1.1. State space averaging 1.2. Linearization 2. Designing of the close loop control of a power converter 2.1. Single input single output control 2.2. Multiple loop control 2.3. Instantaneous current control 2.4. Formulation of control strategy 3. Studying the performance of power converters in close loop 3.1. Simulation and verification of control

strategy 3.2. Importance of feedback and feedforward loops 3.3. Effect of disturbances on the performance of power converters 3.4. Effect of perturbation / variation in elements of power converters 3.5. Impact on start-up transients 3.6. DC and AC type input references and controller performance 4. Significance of close loop responses of a power converter with respect to change in close loop bandwidth and phase margin 5. Demonstration and Experimental verification of some of the modules 5.1. SMPS response and control 5.2. DC bus voltage control of DC-DC converter

EE6270 **1**
Grid Integration of Pv Systems

Equivalent circuit representation of a PV array, different configurations of a PV system (i.e., battery-backed, non-battery backed, single level power conversion, two-level power conversion, centralized configuration, string configuration, multi-string configuration), MPPT control, LPPT control, issue of partial shading.

EE6297 **2**
Modeling and Analysis of Electromagnetic Transients

Principles of transient modeling of lumped circuits, Computer methods for solving electromechanical transients, traveling wave phenomena, modeling of transmission lines, frequency dependent transmission line modeling, modeling of transformers, Transients in 3 phase circuits,transient models for electrical machines, analysis of switching and fault transients, development of electromagnetic transients program (EMTP)

EE6300 **3**
Speech Signal Processing

Speech signal production, acoustic phonetic characterization, classification of sounds based on place and manner of articulation, source-filter model of speech production, short-term spectral analysis of speech, linear prediction analysis, cepstral analysis, spectral distortion measures, vector quantization, Gaussian mixture modelling, dynamic time-warping, hidden Markov models, development of speaker and speech recognition systems, speech enhancement.

EE6307 **3**
Speech Systems
▷Basic Calculus, Probability and Random Processes, Digital Signal Processing and Machine Learning

Feature Extraction: Acoustic theory of speech production and parametric representation of speech signal Automatic Speech Recognition: Template matching approaches, hidden Markov models, deep acoustic modeling, language modeling Speaker Recognition: Gaussian mixture modeling, universal background models, minimum divergence criteria, probabilistic LDA, system building Speech Synthesis: Text analysis, Pronunciation, prosody, waveform generation using unit selection, HTS and wavenets, voice building and modification.

EE6310 **3**
Image and Video Processing

Review of linear algebra, 2D Fourier transform, 2D sampling and reconstruction, 2D DTFT, Human visual perception — spatial properties: physics, biology, empirical understanding, and image fidelity criterion, Image scanning and display: half-toning, dithering, error diffusion; RGB and CMYK systems, Image enhancements — Point operations: display calibration, dynamic range compression, histogram equalization, color mapping, (changing color coordinates, pseudo-color, false color), Edge enhancements, filtering, Image restoration: degradation modeling, Inverse filtering, Wiener filtering, cleaning of additive and multiplicative noise, Image compression: lossless, Image compression: lossy — predictive coding, transform coding, Karhunen Loeve transform, Discrete cosine transform, wavelet transform, quantization, subband coding, JPEG standards, Human visual perception — temporal properties: spatio-temporal modulation transfer function, and fidelity criterion for video, Analog and digital television, video conferencing, Video restoration, Video compression: Motion estimation and compensation, MPEG standards.

EE6320 **3**
Wireless Sensor Network

Introduction to WSN, History and Applications Wireless Sensor Node Architecture-System level - Main components with detailed description, Microcontroller, Communication (RF) module, Sensors (depending on application) and signal conditioning, Memory, Power Supply, Battery Management, Energy Harvesting Wireless Sensor Network Architecture-Topology/Network Structure, Power Management, Physical, MAC, Routing, IEEE802.15.4 Standard and ZigBee,Synchronization, Localization, Data Aggregation and Data base management, Sensor Network Platforms and Testbeds-Operating Systems: Tiny OS, Contiki, Hardware testbeds, Libelium WASP motes, Crossbow Motes, Weather monitoring Systems and eKo motes, System Level discussion on specific applications, Environment monitoring, Green buildings, smart micro grids, green ICI, Health care - BAN

EE6327 **3**
Statistical Learning Theory
▷Basic Calculus, Probability and Random Processes and Machine Learning

Classification and kernel methods: reproducing kernel Hilbert spaces, Fourier properties and analysis, randomized and low-rank approximations Uniform convergence: uniform laws of large numbers, VC dimension, entropy integrals, Rademacher complexity Concentration and risk bounds: Concentration inequalities and applications, Statistical consequences

EE6330 **3**
Advanced Cellular Communications

Introduction to cellular networks. Link budget, propagation models, statistical channel models, Spatial MIMO channel model, SINR distribution in full frequency reuse-1 network; OFDM transmitter and receiver, Coding for multipath frequency selective

channels, code rate diversity trade-off, DFT-precoded-OFDM (SC-FDMA) modulation, Frequency domain MMSE and MMSE-DFE equalizers for DFT-precoded-OFDM, Synchronization, channel estimation, frequency offset correction techniques for OFDM/DFT-precoded-OFDM systems; Capacity of single user MIMO channel, Transmitter diversity methods, Spatial multiplexing (SM), Capacity of MU MIMO in downlink: ZF/MMSE transmit precoding, vector perturbation techniques; Interference channels: Degree-of-freedom for K-user interference channel, interference alignment, multi-antenna MMSE; Distributed MIMO network architectures: Co-ordinated multi point transmission (COMP) with full channel state feedback, limited feedback techniques; Opportunistic scheduling in cellular networks. Proportional fair multi user scheduling in noise and interference limited networks. Best-band scheduling, Traffic modeling, scheduling with QOS constraints, cross-layer optimization; Miscellaneous topics: Channel quality (CQI) computation, Pilot design, CQI stability, Control channel design, power control, Hybrid ARQ, Energy efficiency, Link and system simulation methodologies.

EE6337 **1**
Deep Learning

Deep feedforward networks, regularization for deep networks, optimization for training deep models, convolutional neural networks, practical methodology and applications Prerequisites: Optimization Theory, Machine Learning, Linear algebra

EE6340 **3**
Cooperative Communications

Introduction to Amplify and Forward (AF) and Decode and Forward (DF) cooperative systems, dual hop and multihop systems, variable and fixed gain relays for AF, receivers for AF and DF systems, BER and outage analysis for cooperative and multihop systems, MIMO Relay systems

EE6347 **1**
Advanced Random Processes
▷Random processes, Information science

Point processes, Markov processes, Hidden Markov models, Gaussian processes, Gauss-Markov processes, Maximum entropy, KL expansion and other properties, Gaussian scale mixtures and Spherically invariant random processes, Applications.

EE6350 **3**
Multiple Antenna Systems

MIMO: Single user MIMO link capacity, Capacity of multi-user MIMO, Degrees-of-freedom for interference channels. Open-Loop MIMO: Design criterion and performance analysis of space-time codes, STBCs, delay diversity, phase-offset diversity, transmit antenna switching Closed Loop MIMO: Equal gain transmission, Antenna selection, eigen mode trans-mission, beam forming with quantized feedback, code books based beam-forming, Multi-user MIMO, ZF and vector perturbation methods Spatial Multiplexing: Maximum likelihood and MMSE receivers, Successive cancellation, Reduced state sequence estimation, BER analysis, SM for ISI channels, generalized MIMO MMSE-DFE Co-channel Interference Suppression: Maximum ratio combining, interference rejection combining, Bit error rate (BER) bounds, interference channels, interference alignment Opportunistic Scheduling: Proportional fair scheduling in multi-user systems in white noise and interference. Traffic models Review of multiple antenna techniques adopted in 4G systems.

EE6357 **1**
Sparse Signal Processing
▷Linear algebra

Sparse signal models, L1 minimization, uncertainty and coherence, greedy and relaxation pursuit algorithms, MAP and MMSE Based interpretations, example applications to denoising and super resolution

EE6360 **3**
Multimedia Communication Systems

Video compression fundamentals: optical flow, motion estimation and compensation techniques. Video quality assessment algorithms: full reference, reduced reference and no-reference techniques in the context of packetized transport. The H.264 compression standard: tools for communication including scalable video coding, multiview coding, configurable video coding. Fundamentals of network programming :TCP, UDP, TCP sockets, clientserver examples. Protocols: Apple HTTP Live Streaming (HLS), Microsoft Smooth Streaming (SS), Dynamic Adaptive Streaming over HTTP (DASH), RTSP and related lower level protocols. Fundamentals of Android: Basics of application development on Android.

EE6380 **3**
Deep Learning

Course syllabus: Background for Pattern Recognition and Machine Learning; A short introduction to feed-forward neural networks and error backpropagation; Analysis of Hopfield networks, Hebbian learning, Lyapunov energy functions and basins of attractions; Boltzmann machines, restricted Boltzmann machines; deep belief networks, sigmoid belief networks, deep autoencoders; convolutional neural networks; Application of deep architectures to speech and image processing.

EE6390 **3**
Wavelets and Subband Coding

Wavelets, filter banks and multiresolution signal processing, Fundamentals of signal decompositions, Discrete-time bases and filter banks, Series expansions using wavelets and modulated bases, Continuous wavelet and short-time Fourier transforms and frames, Applications: signal compression, image restoration, compressive sensing.

EE6410 **3**

Role of Signal processing in healthcare - Case studies (1. Foetal ECG separation from

Biomedical IC Design	maternal ECG, 2. ECG feature extraction, 3. EEG analysis, 4. EMG analysis; to help readers understand where signal processing is used), Different types of signal processing techniques; Remote healthcare: technology driven next-generation healthcare - Need of remote healthcare, Overview of remote healthcare architecture, Role of Technology; Signal processing for remote healthcare: Potential Challenges; Overview of Biomedical signal processing techniques; Detailed discussion with various case-studies (will address some of the well-known signal processing techniques in greater details and will also illustrate how these are used in the real life problems); Traditional Signal Processing algorithms vs. Practical Constraints; Need of an holistic view of Algorithm and VLSI Architecture ; Technology for next generation bio-medical signal processing; Hardware complexity analysis of resource constrained system; Computational Delay analysis of resource constrained system; Trade-off analysis : Arithmetic complexity vs Signal parameters; Wireless Sensor Networks for Healthcare; Wireless Sensor Node Architecture and Design, Wireless Sensor Network Architecture; Wireless Sensor Protocol Stack - Layered architecture: Physical, MAC, Network, Transport and Application; Physical Layer Technologies - RF Wireless communications, Modulations, Wireless channel effects, Channel coding, Error Control, Some example Transceivers; Medium Access Control - Design aspects, MAC protocols classification and analysis, MAC for healthcare; Network Layer - Routing in Sensor networks, Different protocol classifications and analysis, Routing for healthcare; Transport and Application Layer- Algorithms ; Cross Layer Solutions - MAC and PHY, MAC and Network, PHY and Network, cross layer modules.; Sensor Data aggregation techniques, Sensor Data storage, Data Management and Processing; Time Synchronisation in WSN: Need and Techniques; Sensor Node localisation: Need and Techniques; Security and Privacy - Authentication and Cryptography; Wireless Sensor and Actuator Networks - Bidirectional Network design, Control on Sensor Networks - design challenges and solutions; Healthcare on Mobile Platforms
EE6640 **2** Queuing Theory ▷Random Processes	Introduction to Queuing Systems, Analysis of a Simple Queue, Introduction to Markov Processes and Markov Chains,Birth-Death Processes,Flow Balance,Basics of Queuing(M/M- Type Queues),Kendall's Notation, Little's Result, PASTA,M/M/1/8,M/M/m/8, M/M/m/m, M/M/1/K Queues,Delay Analysis, Departure Process,Burke's Theorem,Method of Stages,Batch Arrivals Problems, Residual Life Approach,Embedded Markov Chain Approach,Analysis of M/G/1 queue, Special Cases of the M/G/1 Queue, M/G/1 Queue with Multiple Vacations, M/G/1 Queue with Batch Arrivals, M/G/1/K- Finite Capacity G/M/1, G/G/1, G/G/m and M/G/m/m Queues Jackson's Theorem, Splitting and Combining Poisson Processes, Norton's Theorem, Mixed Networks, QNA, Introduction to Discrete Time Queues
EE7110 **3** More Than Moore Electronics	3-D ICs Fabrication, Modeling andDesign Challenges, Molecular Electronics Fabrication, Modeling Challenges (Bottom up approach), Other Si electronics
EE7120 **2** CMOS Sensors	Course Outline: Introduction to sensor technology, CMOS compatibility, Inertial sensors, Biosensors, Gas sensors, Acoustic sensors, magnetic sensors,ASIC design for sensors, design of application specific amplifier, noise considerations, low power, data conversion, layout issues for CMOS analog/mixed circuits Brief Description: This focuses specifically focuses on the understanding of sensors and CMOS circuits. This understanding is necessary to integrate sensors onto a CMOS chip to achieved sensors with integrated electronics. The sensor input and output define the design consideration of circuits and the cmos circuits puts constraints on the choice of materials/ mechanism that can be used for designing sensors. An understanding of both domain gives an added advantage for both circuit engineer as well as sensor technologist.
EE7210 **3** Smart Grids	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.
EE7220 **3** Microgrid Operation and Control	Motivation behind microgrid, ingredients and architecture of a microgrid, distinct features of a microgrid, V-I characteristics of photovoltaic and fuel cells, maximum power point tracking and limited power point tracking of photovoltaic plants, principle of operation of wind generators, introduction to doubly-fed induction generator, utilizations of energy storage devices and plug-in electric vehicles, voltage and frequency control, droop controller tuning, source power output control, islanded and grid connected modes of operation, transition from one mode to another mode, introduction to virtual

synchronous generator.

EE7230 **3**
Wide Area Monitoring, Protection and Control
▷EE5247, EE5257

Concepts of static and dynamic phasors, time synchronization, time stamping, phasor estimation, frequency estimation, phasor concentration, PMU standard, WAMS architecture, online transient stability monitoring, state feedback control basics, classification of power system oscillations, WAC architecture, state feedback, output feedback, generator state estimation, treatment of communication delay, H_2 norm optimization, $H_{infinity}$ norm optimization, treatment of structural constraints.

EE7310 **3**
Cognitive Radio

This course provides an introduction to cognitive radios, a new type of radio that will be capable of cooperatively adapting transmission modes, channels, and protocols to make the best use of the available spectrum. Such radios will include wideband receivers and transmitters, with many of their functions implemented in software, rather than hardware, to enable greater flexibility. While the most commonly cited example of uses of such radios is sharing of under-used portions of the spectrum with licensed (primary) users, the basic technology also can lead to improved uses of the ISM bands. In addition, the cooperative and adaptive nature of the radios has large consequences for jamming/anti-jamming in military communications, representing both a threat to current systems and an opportunity for their evolution to more secure modes. The course provides a background in the technology that makes these radios possible as well as providing guidance on their benefits in multiple access systems.

EE7320 **3**
Immersive Multimedia

Camera modeling and calibration; Image stitching and mosaicing; Stereo vision and depth perception: parallel and non-parallel optical axes; Multicamera array: geometry and calibration; High-resolution image based on camera array; Self-configurable camera array; View-free video; 3-D Reconstruction based on multiple views: mathematical frameworks and algorithms; Compression and the compressive sensing approach; Basis selection: Finite element method, Proper orthogonal decomposition, Wavelets, Wavelet packets and derivatives; Architecture of 3-D video and telepresence system; Concept of space sharing in practical implementation; 3-D rendering and display with emphasis on light-field reconstruction;

EE7330 **3**
Network Information Theory

Probability basics and the weak law of large numbers, method of types and the strong law of large numbers, Sphere packing lemma, channel coding theorem, Type covering lemma, Distortion-abstracted source coding theorem, Lossless coding theorem, Rate-distortion theorem, Type covering with side information, Distortion-abstracted source coding with side information problem and coding theorem, Slepian-Wolf theorem for lossless coding with side information, Wyner-Ziv theorem, Two-terminal distortion abstracted problem with side information -Application of Markov lemma and modular construction, Slepian-Wolf theorem for multiterminal source coding, Wyner-Ahlswede-Korner theorem, Berger-Yeung theorem - without and with side information, General two-terminal source coding problem: unified structural view, multi-letter coding theorem - direct statement and converse, Special cases - Two-terminal Jointly Gaussian problem under MSE distortion (Oohama and Wagner-Tavildar-Viswanath solution), Two-terminal binary Hamming problem, Korner-Marton modulo-two sum problem with symmetric source distribution, Issues in network source coding - Information irrelevance at encoder, Vanishing error versus vanishing distortion, Potential entanglement between independent joint sources and other advanced topics, Channel coding as a game - Covert channel, data hiding capacity, Multiple access channel, Gelfand-Pinsker theorem for channel coding with state information, Relay channel, Degraded relay channel, Broadcast channel, Degraded broadcast channel, Writing on dirty paper, Gaussian broadcast channel, Interference channel, Issues in channels networks - Network capacity and advanced topics.

EE7340 **2**
Special Functions in Communications.

Course Description: Introduction to Gamma Functions, Beta Functions, Hypergeometric Functions, Orthogonal Polynomials, Bessel Functions. Contour integral representations of special functions. Special functions in communications: statistics of decision variables encountered in fading channels and BER analysis.

EE7350 **3**
Adaptive Signal Processing

Fundamentals for adaptive systems, mean-square estimation, Wiener filters. Introduction to adaptive structures and the least squares method. State space models. Kalman filters. Search techniques: Gradient and Newton methods. LMS(least mean squares), RLS (recursive least squares). Analysis of adaptive algorithms: Learning curve, convergence, stability, excess mean square error, mis-adjustment. Generalizations of LMS and RLS.

EE7370 **2**
Markov Chains - MAC Modelling

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

EE7390 **3**
Pattern Recognition and Machine Learning

Introduction to PRML; General Notions: Parameter estimation, overfitting, model selection, curse of dimensionality, bias-variance tradeoff; Supervised Learning (Regression and Classification): Density estimation, Bayes decision theory, generative vs. discriminative models, Linear Methods: linear and logistic regression, generalized linear models, linear discriminant functions for classification, support vector machines etc., Nonlinear methods: kernel methods, nearest neighbor,
neural networks etc., Unsupervised Learning (Clustering and Density Estimations): K-means clustering, vector quantization, Gaussian mixture models, autoencoders, dimensionality reduction (linear and nonlinear) Handling Sequential Data: Hidden Markov models, and Linear Dynamical systems.

EE7710 **3**
Probabilistic Models of the Brain

Introduction: Brain under the hood: the neuron, ion and ion channels, cable theory, simple brain models. Perception: Bayesian modeling of visual perception including depth, velocity and motion, Information theoretic approaches to neural coding and parameter estimation. Neural function: Natural image statistics, probabilistic network model of population responses, models for spiking populations - sparse codes, restricted boltzmann machines, predictive coding.

14.11 Department of Liberal Arts

FC5704 **1**
Engineering And Democracy

None

LA1020 **1**
Psychology Of Well-being

Well being is one of the most popular topics in positive psychology. This is a relatively new approach that focuses on positive aspects as opposed to the psychopathological perspective of traditional psychology. This course will trace research in the area of well being. Relevant concepts such as positive emotions, character strengths and resilience will be introduced and their relation to well being will be examined. Positive psychology interventions that enhance subjective well being and meaningfulness in life will be explored.

LA1030 **1**
Introductory Economics

- Ten Principles of Economics
- Thinking like an Economist
- Interdependence and gain from trade
- The Market Forces of Supply and Demand
- Elasticity and Its Application
- Supply, Demand, and Government Policies
- Consumers, Producers, and Efficiency of Markets
- The Costs of Production

LA1040 **1**
Post-colonial Studies: A Critical Introduction

This course introduces fundamental concepts in the Postcolonial Studies. It also focus on the broad political contexts for the emergence of this discourse, the major departures that it makes from the western discourses and its relevance to Indian theory production. The course involves in analyzing some texts which are considered seminal in the discipline both in the western and Indian contexts.

LA1050 **1**
Introduction To Western Art

In this course, we will explore Western Art—especially painting and architecture—from its beginnings in pre-history to the present. We will explore different media and styles that evolved over the millennia, and develop a vocabulary for speaking about works of art. Since art always grows out of its social context, art's dialogue with society will also be of special interest. And, of course, we will study in detail magnificent paintings, buildings and sculptures!

LA1067 **1**
Origin Of Ethics In Political Theory

First philosophical contemplations about abstract ethical notions like virtue, truth, valor, wisdom, love etc took place in ancient Greece in 6th century BC. These philosophers have incorporated debates and analyses on these abstract notions in most of their discourses on metaphysics, politics, ontology, rhetoric and aesthetics etc. This course explains the students the importance of looking at how and why they originated and more importantly what were they like in their nucleus form. Greece philosophy matured into its fullness in a span of less than a century with the emergence Socratic field in 5th century. This ancient Greece philosophy has created an epistemological base for all the later political theories despite their ideological moorings. In brief, this course introduces the students to a political universe which for the first time (or at least according to recorded data) tried to grasp several notions related to what the current generation calls 'ethics', its importance to human kind and more importantly how we can apply 'ethics' to

solve problems that arise in a society from time to time.
Presocratic Period: Views of Milesians (Thales, Anaximander and Anaximenes) on the origin; Pythagoras theory of harmony, soul's transmigration and reincarnation; Herclitus theory of "all is flux"; Eleatics (especially Zeno of Elea) counter to Herclitus: Empedocles and Anaxagoras on pluralism; Greek Atomism with special reference to Epicurus; Sophists' relativism and extreme skepticism (with specific reference to Protagoras); Socratic Period (Athenian Period): Socrates passion for dialogue and critical reasoning; his debate on what is (and why something becomes) right and/or wrong/ truth and how to arrive it, virtue etc; his disagreement with Sophists; why the then Athens daunted of him/reasons for his capital punishment;
Plato's admiration for Socrates (in the sense how Plato tried to carry philosophical legacy of Socrates); Immorality and the Forms; Philosopher King (virtues in human soul; education and value of justice; Allegory of Cave;
Aristotle: Ethics and Virtues; nature of virtue. Hellenistic Period: Major differences between Hellenistic and Pre-Hellenistic political theories and changes in their political system from participatory government to highly centralized state; Epicureans; Stoics; Skeptics; Neo-Platonism by Plotinus.

LA1077 **1**
Psychology Of Interpersonal Relationships

We are social creatures and are in constant need to relate and orient ourselves towards animate beings. This course is designed as an overview to the field of interpersonal relationships, focusing on the psychological processes of human relationships. We will utilize major theories of interpersonal relationships, such as evolutionary, attachment, interdependence, and social exchange theory. We will also cover topics such as how relationships develop, family and communication, attraction, how relationships break down and so on. The course is
- Introduction
- Evolutionary theory
- Attachment theory
- Social exchange theory
- Relationship development and maintenance
- Family
- Attraction, love, jealousy
- Relationship breakdown and dissolution

LA1080 **1**
The Sociology Of Digital Media: A Global Perspective

This course focuses on the sociology of new media technologies, with a specific aim to anchor them within select theoretical debates and in specific geographic contexts. The course is intended to contribute to an understanding of impacts on individual and society through the use of new digital media tools [example the internet, Social media, mobile phone technologies and devices]. Many of the case studies, supporting theory, will center on people in cross-cultural, resource-poor and emerging market settings [for example, developing countries, the urban slum etc…].
The course will selectively but succinctly and comprehensively understand digital media:
As everyday social practice in multiple contexts: where is it found [social geographies], who uses it [ownership], its social learning [sharing and skill building].
As means to achieving social goals: From downloading latest Bollywood movies, chatting on social network sites and virtual gaming.
Theories that frame and analyze digital media behaviors Example, Facebook, Twitter, Gaming, Multi-media, Search etc.
Case-studies from the global North and South highlighting contemporary trends and their interaction with traditional media
As emerging economies globalize and urbanize rapidly, and users in the global south become 'prosumers' or more critical consumers and creative contributors of digital content, we require a shift in approaching new media users with a more open-ended and explorative perspective. Thereby, the motivating question for our course is what are the implications and impacts of new media as leisure (entertainment/pleasure/ play) artifacts and as professional tools for social mobility especially in the contexts of developing economies and emerging markets. This course will cover interesting social transformations happening in the domain of communication and information channels and, consequentially, the shift registering through social media behaviors and practices. This class has no pre-requisite requirements and open to students from any background. Students will be continuously evaluated with periodic quizzes/short tests and a course end test that will gauge student ability in engaging with and comprehending the course readings and class room discussions.

LA1100 **1**
Information Technology And Development:contemporary

A sociological understanding of development in specific social contexts and the role of specific technologies in aiding it. The question we ask is how technology seeks to address the needs and aspirations of people who are increasingly consuming technologies and

Debates And Praxis

services despite inadequate infrastructures and resources.
Highlight with case-studies from India, Africa, Latin America, Sri Lanka and Bangladesh. These will provide a ground-view of processes aiding deployment and adoption of ICTs
Offer a critical lens to evaluate the processes and impacts ICT for D field deployments. This would provide a well-rounded and practical perspective on issues of assessment and successes of development projects

LA1110 1
Financial Markets

- Role of financial markets
- Interest rates and their role in valuation
- Money Market
- Bond Market
- Equity market
- Foreign Exchange Market

LA1120 1
Introduction To Social Psychology

This course is an introduction to the field of social psychology, one of the important sub-fields of psychology. While psychology is generally concerned with understanding and explaining individual human behaviour, social psychology can be described as the scientific field concerned with the understanding of individual behaviour in social situations. It explores how human thought and behaviour is influenced by the actual or imagined presence of others. How and why do people behave differently in different contexts? Why are some people more helpful while others more aggressive? What distinguishes good leaders from non-leaders? Why do we believe claims made by advertising companies which are obviously unreasonable? What are some of the techniques used to persuade people to change their minds? Why do people have extreme prejudices and stereotypes and how can these be overcome? These are some of the important questions that concern the field of social psychology.

LA1130 1
Indian Gods In Japan: History, Identity, And Supremacy In Society

This course is about Indian gods worshipped in Japan. The course projects insights into the socio-cultural scenario within which the worship of Indian gods in Japan is contextually located.

LA1140 1
Introduction To The Short Story

Designed for the beginning student of literature, this course provides an overview of the traditional and modern approaches of narration used largely by the short story genre. By reading a selection of short literary narratives that represent various cultures across the world, this course examines how plot and authorial intent function in short stories to give rise to a variety of forms presently associated with this genre. The student is expected to read and critically interpret these narratives and submit their responses in the form of both oral and written presentations.

LA1150 1
Cultures Of the World

This course will introduce students to the field of social and cultural anthropology and sociology. They will be exposed to different cultures of the world, and how social and cultural attitudes and behaviours are so different and yet so similar, across cultures. The course will enable them to understand cultures in the Americas (north and south America), Asia, Europe and Africa. Students will also learn to understand and appreciate ethnography as a method and an approach to study world cultures. It will give them an international exposure to some major issues of interest in the 21st century- about environment, globalisation, media and health. Students will read chapters from the assigned textbook, as well as articles, and will watch documentaries in class. Assessment will be based on response papers written regularly about the readings, and a research paper. based on a topic chosen by the student.

LA1200 1
Introduction To Psychotherapy

This course will present an introduction to the field of psychotherapy, including a theoretical understanding of different therapies such as psychodynamic and psychoanalytic theories and approach, humanistic-experiential theories and approach, group therapy. The aim of this course is to give students an idea about the various approaches of counseling in different settings. The course especially aims to sensitize students the holistic nature of this field and its subsequent benefits. This course is practical and interactive in its style of instruction, with student participation being particularly recommended. The mode of evaluation for this course is through assignments and presentations.
Topics:

- Transactional analysis
- Psychodynamic and psychoanalytic theories and approach
- Humanistic-experiential theories and approach
- Cognitive-behavioural theories and approach
- Group therapy
- Family and couples counseling

LA1220 **1**
Understanding Hyderabad And Its Heritage

This course takes an in-depth look at the history and heritage of the city of Hyderabad. With more than four hundred years of history, including sites suggested for inclusion in the world heritage list, and simultaneously traversing the 'global' tag, Hyderabad has lots of stories to tell. Through assigned readings and lectures, field trips to selected heritage sites, and interviews with residents, students will get to understand various facets to the city of Hyderabad. Assessment will be based on individual written essays and group projects. This course involves significant amount of reading and writing, and discussions in class.

LA1230 **1**
Introduction To Medical Humanities

The course will focus on the interpretation of medicine from the world of arts, literature, history, anthropology and psychology. By looking at paintings, biographies, novels, ethnographies, and films, the course will engage in detailed discussions on some key topics such as narrative medicine, history of medicine, cross-cultural communication, disability studies and lived experience. Field trips to practitioners of different systems of medicine will be undertaken. Readings will be followed by interactive class discussions. Students will also choose a topic to work on for a research paper. Assessment will be based on written essays and class presentations.

LA1240 **1**
Literature And Science

This course explores the dialogue between literature and scientific disciplines over a period of about 200 years. The split between the arts and sciences is relatively recent in the history of human knowledge and creativity: many of the great artists of the Renaissance or the 17th century, for example, would also qualify as great scientists in the way we understand the word 'science' today. And both artists and scientists have, despite appearances to the contrary, a continuing history of speaking to and about each other—even if sometimes what they have to say might not be very flattering to the other party. It is this history that we will explore and try to learn from. We will look at classic science fiction like Mary Shelley's Frankenstein and Philip K. Dick's Do Androids Dream of Electric Sheep?; we will read the work of highly articulate scientists like Richard Feynman and James Watson; we will look at what poets make of quantum physics, biochemistry and—of course—fractals. We will occasionally look at visual material including films and paintings.
The course has an optional creative component: assignments and projects can be works of creative writing. This course involves close reading of literary texts, so those who take this course should be comfortable with reading English literature.
Plagiarism warning: Copy-pasting from the internet or other sources in your assignments will lead to a failing grade.

LA1250 **1**
Modern Telugu And English Poetry: A Comparative Study Of Cultural Politics

Poetry has been written from ancient times in order to fulfill several purposes like personal satisfaction, royal or divine aggrandizement, fascination, political articulation etc. However, it keeps on changing its form and content with the changing times and history and Telugu poetry is no exception from it. It is a perfect prototype of modern poetry written from colonial and postcolonial background and it strongly reflects the trends of the cultural politics, which are due for any other postcolonial nation. Therefore, this course requires at least two types of attention: One is thematic and the other is theoretical. In other words, some of the major cultural studies theory will be applied in order to understand the thematic universal of postcolonial poetry.
Unfortunately, the only question that has been contemplated in the vernacular about art is: 'is art for the sake of art or not.' Though this question carries its own ideological impinges it also greatly delimited theory on poetry from growing. On the other hand western world especially ancient Greece has given serious thought into the subject of poetry. For instance, Aristotle had given a rigorous thought to poetry and argued that it is basically a mimesis (imitation) and interestingly Plato hated poetry for the same reason. After several thousands of years, now in postcolonial times, some of the nations from Caribbean perceive its poetry as essentially hybrid (close to mimesis). Thus this course deals with several questions pertinent to comparative analysis. These questions are broadly: Does India, a postcolonial nation produce hybrid poetry like Caribbean? If not, why? In other words, why Indian vernacular fail to produce poetry on certain cultural experiences like its other postcolonial sister like Caribbean? Why vernacular poetry fails to be enough imaginative? Etc.

LA1260 **1**
Fundamentals of Organizational Structure

Course Objective: To help students understand the elements of the structure of an organization and the role of organizational structure in organizational effectiveness. This course will be very useful for engineering graduates to understand the design behind social structures like organizations.
Brief Course Outline:
- Defining organizations
- Fundamental concepts in organizational design
- Elements of organizational structure

- Factors influencing organizational structure
- Role of organizational structure in organizational effectiveness

LA1270 1
An Introduction To Human-computer Interaction And Its Interface With The Social Sciences

Quote: "A sushi restaurant puts sensors on its plates to assess, in real time, what's being eaten so it can adjust its food offerings" [Goodman, The Atomic Age of Data, 2015]" End Quote.
This course is an introduction to the field of Human-Computer interaction research with a focus on 'human' and how the HCI domain interfaces with the social sciences. The course begins with a selection of seminal work that establish the HCI domain: interactive systems/techniques, design and user interfaces. We will then move on to topics including social and context aware computing, design research and evaluation methods.
Radically different ways of interacting with computationally based systems are possible, ranging from the visual [surfaces, input devices] to the invisible [sensor technologies, back end processors] and importantly social [which means non-technological] affectations triggering diverse ways of interfacing with technology.
This course will center on the processes and challenges of ideating, designing and evaluating technologies as products, their usability and immersion into the social contexts of users. We will study contextual design as a field that emerged in response to the challenges of designing for context and usability. Another important strand in this course will dwell on the sociological aspects of HCI and explore the 'mediation' of technology use by a range of contextual situations: socio-cultural obligations, habits, values, infrastructure, material objects and not in the least family, kinship and human bonds. Some examples of the above are:
Understanding social interactions with a webcam as an important new development in communication interfaces and its widespread adoption in the real world supporting family relationships, business work flows and social networking. Another example will be looking at technologies driven by data science, like mobile marketing analytics, and their consequences for society.
This course has no pre-requisites and is open to students from any background. Students are expected to do all of the readings. Students will be evaluated with a quiz or a test and a presentation that will gauge student ability in engaging with and comprehending the course readings and class room discussions. The class test and the presentation will be based on the class lectures and readings assigned for the course

LA1280 1
Globalization And Society

The objective of this course is to provide students with a sociological perspective on the set of processes commonly referred to as 'globalisation'. It will look at the ways in which social and cultural factors affect attitudes to family and kinship, education, employment, migration, media images, and gender ideologies. Through looking at empirical evidence from different parts of the world, the course aims to educate students on the effect of globalization processes in people's lives.

LA1290 1
Iintroduction To The Novel

Designed to introduce the student to the novel as a literary genre this course provides a broad historical overview of the development and rise of the novel. Focusing on narrative strategies, plot development, and characterization among others, used in their various forms and guises by the novel, this course seeks to help the student understand, evaluate and interpret how this genre functions as a medium of dialogue between literature and society. The student is expected to articulate her/his responses both as class discussions as well as written presentations.

LA1300 1
General Fiction: Thrillers

This course examines two representative works of genre fiction, namely, psychological thriller and detective fiction. By focusing on the connections between literary artefacts and the social context, the course aims to familiarize the student with genre fiction as a discursive practice whose socio-cultural roots are embedded deeply in history. It also provides a crucial link between literature and other aesthetic media of communication such as films and television by reading literary works in tandem with their audio-visual adaptations. The student is expected to read and interpret texts and contexts and present an analysis of the same through class discussions and written assignments.

LA1310 1
General Fiction Ii: Horror And Science Fiction

This course analyzes classic works of horror and science fiction to explore the relationship between literature and socio-cultural realities, specifically with regard to development of global politics and history over the last two centuries in Europe and America. In addition, the literary texts chosen for this course demonstrate how the fantastical realms of horror and science fiction are not only elemental to human imagination but also progenitors of ideologies around which social reality is constructed.

LA1330 1
Urban Futures

How are cities of the future being imagined and planned? Who is being imagined as a citizen of emerging urban-scapes? Whose aspirations get factored into city-planning and whose are ignored? What kinds of expert knowledges are at play? As cities worldwide experience dramatic growth, attending to associated social, political, environmental,

technological challenges become ever-more urgent. This course examines some key themes in contemporary debates in urban studies to understand the kinds of challenges rapid urbanization poses, and ways in which different stakeholders are responding to these. This is a research based course, in which students will proactively work with government reports, planning documents, and scholarly literature to understand the problems and pitfalls of urban growth. In particular, we will collectively seek to analyze the current masterplan for the greater Hyderabad metropolitan area, Hyderabad Masterplan 2031.

LA1340 1
Understanding Resilience: From Research To Practice

This course will apply concepts and theories from resilience research into practice in everyday life. Resilience research uses the positive psychology framework to understand how some individuals display positive adaptation despite adversity while others succumb to similar circumstances. The four waves of resilience research will be presented to introduce key concepts, landmark studies, and theoretical perspectives in the area. Application of research findings in everyday life will be discussed with reference to different challenges, protective mechanisms, and outcomes of positive adaptation. This will be achieved through the exploration of case studies and available literature.

LA1350 1
Thinking About Gender

Gender and its construction require specific forms of negotiation and understanding. Social mores determine the identities and meanings surrounding the practice of gender. This course aims to introduce students to the ways in which gender and it construction works in social practices and ideas. Specifically, the course seeks to engage with ideas of masculinity, femininity, and the ideological frames within which they are set. The course also looks the concept of intersectionality, and the ways in which gender interacts with other social practices and structures.

LA1360 1
Language and Logic

This course will explore the relationship between natural language and logic. The central questions to be addressed are: (i) how is logic represented in natural language? (ii) is there any difference between logic expressed in natural language and logic in general? (iii) how can we understand logical expressions through natural language and vice versa? and (iv) does linguistic logic reveal something about cognitive structures?

LA1370 1
Cross-cultural Virtual Teams

Working in cross-cultural work teams have become a common phenomenon in organizations. Often the members of these teams are not collocated and work from varied geographical locations, sometimes belonging to different time zones. Employees working in these teams face unique challenges rising due to differences in cultural orientations and values of the members, communication barriers caused by technological mediated communication and synchronizing work among different time zones etc. With this background this course aims to introduce students to these challenges of working in cross-cultural work teams through a practical project. This project will involve students registered in this course and students from Department of Applied Psychology, University of Applied Sciences, Northwestern Switzerland.

LA1380 1
Sustainability

Sustainability, Sustainable living, Sustainable development, these are now buzz words commonly used in everyday discourse. This course aims to unpack these seemingly self-explanatory terms and probe in-depth what it actually means to talk about sustainability. We will place the debates and arguments about sustainability within the larger socio-cultural contexts and explore how different peoples, places, and cultures might approach the issues involved, as they impact on both environment, and livelihoods. A major part of the course will be hands-on experience looking at various issues that pertain to sustainability, within the campus, and in the nearby areas.

LA1430 1
Understanding Resilience

This course will apply concepts and theories from resilience research into practice in everyday life. Resilience research uses the positive psychology framework to understand how some individuals display positive adaptation despite adversity while others succumb to similar circumstances. The four waves of resilience research will be presented to introduce key concepts, landmark studies, and theoretical perspectives in the area. Application of research findings in everyday life will be discussed with reference to different challenges, protective mechanisms, and outcomes of positive adaptation. This will be achieved through the exploration of case studies and available literature.

LA1450 1
Personality Psychology

Personality Psychology addresses questions about how individuals develop characteristics that make them unique from each other, why they act and behave the way they do, historical issues and controversies that personality psychologists have encountered, techniques used in assessing personality, and how the study of personality psychology maybe applied to everyday life. This course will introduce the students to some of the most prominent personality approaches. Since the organization of personality is a complex one, shaped by many influences such as genetics, environment,

and internal conflicts, one may recognize that there is no one approach that would present an integrated picture of human personality. The aim of this course is to provide an overall perspective that includes a multitude of factors in understanding personality. This would help in application of concepts from personality psychology for both personal development as well as in understanding others.

LA1470 1
Philosophical Perspectives On Human-technology Interactions

This course will look at basic philosophical questions surrounding AI and Humanity: What does it mean to be 'human' in the 21st century, and how does the growth of AI technologies modify the terms of this question? Can traditional Cartesian dichotomies still be operative in the face of AI? What alternative models of consciousness and cognition do we have to generate in order to address the ontological challenges posed by AI? How does one place the AI debate within larger discussions about the interactions between technologies and societies? Insights from both the Analytic and the Continental traditions in philosophy will be used to address these questions.

LA1480 1
Artificial Intelligence In Literature And Popular Culture

The art of the twentieth century and after has moved uncannily close to the impersonality and automation of thinking machines, embracing forms of mediated, augmented, and suspended consciousness provided by algorithms. The central premise of the course is that as a set of practices founded on principles of artifice as well as the idea of a distinctly 'human' creativity, the Arts have a powerful but conflicted affinity with the premises of AI. Using examples from the visual arts, film, and literature, this course will explore the ways in which popular culture has represented Artificial Intelligence as a key domain for reflecting upon the category of the human. The course will also provide students with tools to interact productively with the visual arts and literary/philosophical texts.

LA1490 1
Socio-cultural Perspectives On Artificial Intelligence

AI technologies shape not only what humans (can) do as part of their daily routines, but simultaneously also transform their very ideas of what it means to be human and how they relate to each other. In other words, core categories of social life–including for example, self and community, agency and autonomy–are challenged and rearticulated as they come to be increasingly mediated by AI technologies. And yet, as empirical social researchers have convincingly demonstrated, such newer conceptions of self, identity, and community do not arise in a vacuum – but rather always build on culturally and historically available templates of thought and action. Building on scholarship in the history and social anthropology of science and technology, this course seeks to understand this mutual shaping of AI technologies and humanity.

LA1500 1
What is AI And Humanity?

This is the introductory course to the LA minor, AI and Humanity. The course will orient students to the scope of the minor through a series of guest lectures and field trips that expose them to various perspectives on the possibilities and challenges that AI technologies imply. Topics covered include, among others, AI in governance, healthcare, innovation, manufacturing, mobility, and the arts.

LA1530 1
Language, Cognition, And Artificial Intelligence

This course will explore the cognitive significance of natural language for AI (Artificial Intelligence) by tracing the foundations of the relationship between natural language and AI to Alan Turing's work. The central questions to be addressed are: (i) what is the cognitive significance of natural language? (ii) why and how is it relevant to the foundations of AI? (iii) what models of natural language hold cognitive significance for AI?

LA1540 1
Artificial Intelligence and Behavioral and Mental Health

How are you today? How do you make sense of this information? What kind of people should I target for my product? These may be questions that will soon be answered by artificial intelligence. Advances in technology are bringing physical and mental healthcare closer to individuals who need it. This course will summarize the need for and advances in AI and behavioural and mental health practice, its significant role in medical decision-making and communication, and how it helps shape targeted service delivery through facilitating segmentation.

LA1550 1
AI And Human-computer Interaction

The course purports to bring a social perspective and the importance of 'lived contexts' in the framing and understanding of man-machine interactions and a grasp of the theoretical and applied frameworks supporting the domain of Human Computer Interactions [HCI]

LA1570 1
Cultures Of Digital Gaming

Designing a video game involves not just coding and programming, but also articulating and writing one's own imagination of the experience of the gamer. But not always are designers able to predict and map the myriad experiences of players. Digital simulations, and the way they are navigated through virtual performances, become highly charged and emotional ways through which gamers think about themselves and the online community, about human capacities and empowerment, about strategy and amusement, about gratification and frustration. This course is intended to introduce students to the way in which virtual and online gaming connects the individual gamer's spatial,

physiological and experiential locations to larger debates around capitalism, aesthetics, technology and identity.

LA1590 **1**
Stories Told Through Pictures: Graphic Novels As Literature

This course will examine Art Spiegelman's Maus and Amruta Patil's Kari as cultural monuments that draw on the visual medium to offer a commentary on highly polemical issues of history and sexuality. We will look at how Maus operates as a work of holocaust literature dealing with issues of genocide, trauma, authorship, and ethics. We will study how Kari reshapes the narrative around urban heterosexuality through the portrayal of same-sex desire and urban alienation. Through rigorous engagement with the two graphic novels and a brief filming of the cinematic rendering, the course will encourage students to close-read cultural narratives and unpack their subtexts.

LA1630 **1**
Psychopathology and Mental Health

This course will present concepts, theories, and research findings in the area of psychopathology and highlight factors influencing mental health. The history, background and contemporary viewpoints on psychopathology from biological, psychodynamic, sociocultural, and cognitive perspectives will be introduced to students. Keywords relevant to the area such as dysfunction versus deviation, psychiatry versus psychology, neurosis versus psychosis, symptoms, syndromes, and disorders will be discussed. Clinical criteria for mental health diagnosis will be presented along with a brief overview of assessment and treatment. Finally, outcomes of mental health care such as the display of optimal functioning despite symptoms will be discussed through the exploration of case studies and available literature. Overall, this course is expected to improve the general understanding of mental health by addressing the popular myths and misconceptions related to mental health and psychopathology.

LA1640 **1**
Introduction to Disability Studies

This course will introduce students to key concepts and ongoing debates in the academic discipline of disability studies. Although issues of impairment and disability are often approached through medicalized discourses, recent scholarship in disability studies has questioned the normative assumptions about 'normal' and 'abnormal' bodies and minds that underlie the medical paradigm of disability. Social science research on disability from anthropology, sociology, psychology, gender studies and the humanities has emphasized disability as an experience that is constructed and produced through historical, social and political contexts. Through engaging with this scholarship, as well as through active class assignments and projects, students will develop a critical approach to issues of diversity and disability. A graded field visit will provide students with the opportunity to observe in practice concepts and theories discussed in class.

LA1650 **1**
An Intrduction to the French Language-level 2

The second part of the course "An introduction to the French language" will provide solid language skills to the students as well as intercultural sensitivity and openness to the world. Through a global simulation ("Voyage en France" - Trip to France), they will have the opportunity to project themselves in real conditions concerning the organisation of holidays and stay in France. This fictive situation will allow the exploration of different scenarios. A great importance will be attached to the intercultural aspects as well as the habits and customs of French people. Varied and authentic supports will be used (video and audio recordings) in order to make the learning process more effective and fun. A prerequisite for this course is that the student has successfully completed the LA1510 "Introduction to French Language" course.

LA1660 **1**
An Introduction to the German Language-level 2

The second part of the course "An introduction to the German language" covers the basic conversational phrases in everyday situations along with providing the participants an insight into the German culture. It includes reading, writing, hearing and speaking skills and a good understanding of the basic grammar of the German language. Major learning outcomes of the course include having simple conversations and small talk about family, daily routine and hobbies; making appointments and visiting a restaurant; organizing a party and going shopping; and understanding the German food culture, their leisure activities and punctuality. A prerequisite for this course is that the student has successfully completed the LA1520 "Introduction to German Language" course.

14.12 Department of Mathematics

MA1110 **1**
Calculus - I

Sequences and Series: Limit of a sequence, monotone and Cauchy sequences and properties of convergent sequences, examples. Infinite series, positive series, tests for convergence and divergence, integral test, alternating series, Leibnitz test. Differential Calculus: Continuity and differentiability of a function of single variable, statement of Rolle's Theorem, Lagrange's mean value theorem and applications.

MA1130 **1**

Double and Triple Integrals: Calculations, Areas, Volumes, change of variables,

Vector Calculus ▷MA1110	Applications. Integrals of Vector Functions: Line integrals, Green's formula, path independence, Surface integral: definition, evaluation, Stoke's formula, Gauss-Ostrogradsky divergence theorem.
MA1140 1 Elementary Linear Algebra	Vector spaces, Subspaces, basis and dimension, linear transformations, representation of transformations by Matrices, linear functionals, transpose of linear transformations, canonical forms. Linear functionals and adjoints, Bilinear forms, symmetric bilinear forms, skew symmetric bilinear forms.
MA1150 1 Differential Equations ▷MA1110, MA1140	Ordinary Differential Equations: First order linear equations, Bernoulli's equations, Exact equations and integrating factor, Second order and Higher order linear differential equations with constant coefficients.
MA1220 1 Calculus- II (Multivariable Calculus) ▷MA1110	Integral Calculus: Definite Integrals as a limit of sums, Applications of integration to area, volume, surface area, Improper integrals. Functions of several variables: Continuity and differentiability, mixed partial derivatives, local maxima and minima for function of two variables, Lagrange multipliers.
MA1230 1 Series of Functions	Functional Series: Pointwise and uniform convergence, basic aspects of Power series, Fourier series.
MA1500 1 Math Foundation	Statements, Quantiers, Operation on sets and functions, Relations, Proofs.
MA1510 1 Introduction to Number System	Countability of algebraic numbers, Transcendental numbers and construction of Liouville's number, Equivalence classes, construction of real numbers (using Cauchy sequences), Fermat's little theorem and using it for Miller-Rabin primality test, Wilson's theorem and Primitive root theorem.
MA2110 1 Introduction to Probability ▷MA1110	Sample space and events, definitions of probability, properties of probability, conditional probability. Random variables: distribution functions, discrete and continuous random variables, moments of random variables, conditional expectation, Chebyshev inequality, functions of random variables. Special Distributions: Bernoulli, Binomial, Geometric, Pascal, Poisson, Exponential, Uniform, Normal distributions, Limit Theorems: Law of large numbers.
MA2120 1 Transform Techniques ▷MA1110	Laplace and Inverse Laplace transform, linearity, Laplace transforms of Derivatives and Integrals, partial fractions, unit step function, shifting on the t-axis, periodic functions, applications of Laplace transform for solving differential equations. Fourier integral, Fourier Sine and Cosine transform, convolution, applications of Fourier transform for solving differential equations.
MA2130 1 Complex Variables ▷MA1110	Complex Functions limits, Continuity, Differentiability, analytic functions, Cauchy -Riemann equations, Laplace equations, Harmonic functions, conformal mapping, Cauchy integral theorem, Cauchy integral formula, derivations of an analytic function,Power series, Taylor series, Laurent series, zeros, singularities, residues, evaluation of real integrals.
MA2140 1 Introduction to Statistics ▷MA2110	Fundamentals of Data: Collection, Summarization, and Visualization; Sampling and Sampling Distributions, Central Limit Theorem; Methods of Estimation, Unbiased estimators; Confidence Interval Estimation: Z-interval, t-interval; Hypothesis Testing, Types of Errors, Rejection Region Approach and p-value Approach.
MA2142 1 Regression Analysis ▷MA2140	Simple and multiple linear regression models. Estimation, tests and confidence regions of the model parameters. Residual analysis, check for normality assumption, Collinearity, outliers. Transformation of response variables, model selection
MA3120 3 Theory of Polynomials	Polynomials, factorization, Inequalities for roots, The resultant and the discriminant, Lagrange's series, Irreducibility criteria, Hilbert's irreducibility theorem, The cyclotomic polynomials, Chebyshev polynomials, Bernoulli polynomials, Hilbert's Seventeenth Problem
MA3140 2 Statistical Inference	Point estimation: Methods of moments and maximum likelihood estimation; Unbiasedness, Sufficiency, Efficiency, Completeness; UMVU estimators, Fisher-Information, Cramer-Rao; Confidence Interval Estimation; Hypothesis testing: Neyman-Pearson, Likelihood Ratio Tests, Chi-Square Tests, t-tests, F-tests
MA3143 1 Statistical Analysis Using R ▷MA 2110, MA 2140	Data organization, Data import–export, Data production and manipulation, Graphical techniques, Conditional statements, Functions. Random variables, Distributions and simulation, Descriptive statistics, Confidence intervals and hypothesis testing, Basic

regression analysis (linear and logistic), Analysis of variance

MA3163 2
Computational Algebra-i Mathematical Computing With Mathematica

Computations in Number Theory, Calculus, Linear Algebra; and modeling, Visualization and Geometry

MA3310 3
Basic Cryptography

Elliptic Curves, Weierstrass and Edwards curves, Factoring using elliptic curves, Primality testing, discrete logarithm problem, Anamalous curves, A Cryptosystem based on the Weil and Tate-Lichtenbaum pairings, Miller's algorithm, Hyperelliptic curves, divisors, Cantor's algorithm

MA3320 3
Diophantine Equations

Lattices, quadratic forms, algebraic numbers, class group, class numbers, Diophantine aspects of elliptic curves, analytic tools.

MA3610 0
Variational Calculus
▷MA1220

Extrema of functionals, Variation of a functional and its properties, Euler's equation, Field of extremals, Sufficient conditions for the Extremum of a Functional, Conditional extrema, Moving boundary problems, Ritz method

MA3620 1
Some Special Functions in Mathematical Analysis

Exponential and Logarithmic function. The Trigonometric functions. The Gamma function. The characterization of Gamma function. Introduction to Fourier Series and Fourier transform.

MA4010 3
Analysis of Functions of a Single Variable
▷MA1110

•Real number system: Field properties, ordered properties, completeness axiom, Archimedean property, subsets of $\mathbb{R}$, infimum, supremum, extended real numbers. Finite, countable and uncountable sets, decimal expansion. Sequences of real numbers, Subsequences, Monotone sequences, Limit infimum, Limit Supremum, Convergence of Sequences.
Metric spaces, limits in metric spaces. Functions of single real variable, Limits of functions, Continuity of functions, Uniform continuity, Continuity and compactness, Continuity and connectedness, Monotonic functions, Limit at infinity. Differentiation, Properties of derivatives, Chain rule, Rolle's theorem, Mean-value theorems, L'Hospital's rule, Derivatives of higher order, Taylor's theorem. Definition and existence of Riemann integral, properties, Differentiation and integration.
Revision of Series, Sequences and Series of functions, Pointwise and uniform convergence, Uniform convergence of continuous functions, Uniform convergence and differentiability, Equicontinuity, Pointwise and uniform boundedness, Ascoli's theorem, Weierstrass approximation theorem, Fourier series

MA4020 3
Linear Algebra

• System of Linear Equations, Elementary Operations, Row-Reduced Echelon Matrices, Gaussian Elimination.
• Vector Spaces, Subspaces, Direct Sums, Bases and Dimension, Linear Maps, Rank-Nullity Theorem, The Matrix of a Linear Map, Invertibility.
• Eigenvalues and Eigenvectors, Invariant Subspaces, Upper-Triangular Matrices, Diagonal Matrices.
• Inner Products, Norms, Orthonormal Bases, Gram-Schmidt process, Schur's theorem, Orthogonal Projections and Minimization Problems, Linear Functionals and Adjoints.
• Self-Adjoint and Normal Operators, The Spectral Theorem for finite dimensional operators.
• Generalized Eigenvectors, The Characteristic Polynomial, Cayley-Hamilton Theorem, The Minimal Polynomial, Jordan Form.

MA4030 3
Ordinary Differential Equations
▷

Introduction: Mathematical modeling using ODE's, Definition of Linearity, Classification of ODE's, Notion of solutions, Methods of solution for first order linear differential equations: Separation of variables, integrating factor. Second order linear differential equations: Homogeneous and non homogeneous differential equations. Series solutions. Initial Value Problem (IVP): Notion of solutions, wellposedness of IVP in the sense of Hadmard. Some examples on unique solution, infinitely many solutions and no solution of IVP – Lipschitz continuity, Gronwall's inequality and uniqueness of the solution of IVP. Picard's existence and uniqueness theorem for IVP. Peano existence theorem. Continuous dependence of solution on initial data. Continuation of solution and maximal interval of existence.
Linear System Theory: Reduction of nth order scalar differential into a system of n first order ODE's. Fundamental matrix solution, space of all solutions as n-dimensional vector space Transition matrix and solution of IVP. Peano-Baker series for computation of transition matrix. Autonomous systems and matrix exponential. Computation of matrix exponential for diagonal matrices, Jordan blocks and other special matrices. Solution of

nonhomogeneous IVP by Duhamel's principle.
Stability Theory: Stability theory for 2×2 systems, canonical form, equilibrium points, node, center and focus. Classification of equilibrium points of nonlinear systems. Lyapunov stability, asymptotic stability and exponential stability Poincar´e-Bendixson theorem, Lienard's theorem.
Boundary value problems: Introduction to boundary value problems. Regular Sturm-Liouville problems. Green's function. Existence of eigen functions. Zeros of solutions. Oscillation results. Comparison theorems

MA4040 **3**
Probability Theory
▷

• Probability Space, Independence and dependence, Random variables and distribution functions
• Random variables and joint distributions, Functions of random variables
• Expectation and moments, Conditional expectation, Characteristic functions, Sequences of random variables
• Modes of Convergence, Weak and Strong laws of large numbers, Central Limit Theorems.

MA4051 **3**
Basics of Programming

Structure of a program, Input and Output Variables and Types, Arithmetic and Relational Operators, Control Structures, Functions, Arrays and Pointers, File Handling.

MA4060 **3**
Complex Analysis

• Spherical representation of extended complex plane, Analytic Functions, Harmonic Conjugates, Elementary Functions, Cauchy Theorem and Integral Formula, Homotopic version
• Linear fractional transformations, Power Series, Analytic Continuation and Taylor's theorem, Zeros of Analytic functions, Hurwitz Theorem, Maximum Modulus Theorem, Laurent's Theorem, Classification of singularities
• Residue theorem and applications, Argument Principle, Theorem of Rouche, Schwarz-Christoffel Transformation.

MA4070 **3**
Groups and Rings

•Binary operation and its properties, Definition of Groups, Examples and basic properties. Subgroups, Coset of a subgroup, Lagrange's theorem. Cyclic groups. Normal subgroups, Quotient group. Homomorphisms, Isomorphism theorems. Permutation groups, Cayley's theorems. Direct and semidirect product of groups. Group actions and Sylow theorems.
Definition of Rings, Examples and basic properties, Zero divisors, Integral domains, Fields, Characteristic of a ring, Quotient field of an integral domain. Subrings, Ideals, Quotient rings, Isomorphism theorems. Ring of polynomials. Prime, Irreducible elements and their properties, Unique Factorization Domains, Principal Ideal Domains, and Euclidean domains. Prime ideal, Maximal ideal, Prime avoidance theorem, Chinese remainder theorem.

MA4080 **3**
Measure and Integration
▷MA4010

• Sigma-algebra of measurable sets. Completion of a measure. Lebesgue Measure and its properties. Non-measurable sets.
• Measurable functions and their properties. Integration and Convergence theorems. Lebesgue integral, Functions of bounded variation and absolutely continuous functions. Fundamental Theorem of Calculus for Lebesgue Integrals.
• Product measure spaces, Fubini's theorem.
L^p-spaces, duals of L^p spaces. Riesz Representation Theorem for $C([a, b])$.

MA4090 **3**
Analysis of Functions of Several Variables
▷MA4010

Functions of several-variables, Directional derivative, Partial derivative, Total derivative, Jacobian, Chain rule and Mean-value theorems, Interchange of the order of differentiation, Higher derivatives, Taylor's theorem, Inverse mapping theorem, Implicit function theorem, Extremum problems, Extremum problems with constraints, Lagrange's multiplier method.
Multiple integrals, Properties of integrals, Existence of integrals, iterated integrals, change of variables. Curl, Gradient, div, Laplacian cylindrical and spherical coordinate, line integrals, surface integrals, Theorem of Green, Gauss and Stokes.

MA4110 **1**
Applied Galois Theory

Revision of concepts from field theory, normal extensions, separable extensions, fundamental theorem of Galois theory, cyclotomic extensions, impossibility of solving quintic equations

MA4113 **1**
Field and Coding Theory

Field extensions, degree of a field extension, algebraic closure of a field, introduction to finite fields and coding theory

MA4120 **1**
Advanced Linear Algebra

Vector spaces, multilinear maps, tensor product of vectors, exterior product, tensor algebra and exterior algebra

MA4133 **2**
Computational Algebra On Polynomials and Ideals

The Division Algorithm. Polynomial Rings. Basic Operations with Monomial Ideals and Modules. Term Orderings and Leading Terms. Gröbner Bases of Ideals and Modules, Buchberger's Algorithm. Computation of Colon Ideals and Annihilators, Computation of Intersections of ideals. Elimination. Diophantine Systems and Integer Programming. Systems of Polynomial Equations

MA4140 **1**
Homological Algebra I

Categories, Functors, Chain complexes, Derived functors, Left/Right Exactness, Tor and Ext. Group homology and cohomology

MA4143 **1**
Time Series Analysis
▷MA 2110, MA 2140

Testing randomness of a time series, test for trend, seasonality test; Estimation and elimination of trend and seasonality, moving average smoothing, least squares method, method of differencing; Mathematical formulation of time series; Weak and Strict stationary, stationary up to order m, covariance stationary; Auto Covariance and Auto correlation functions of stationary time series and its properties; AR, MA, ARMA, seasonal, non-seasonal and mixed models; ARIMA models; Invertibility of linear stationary processes; Auto covariance generating function; Parameter estimation of AR, MA and ARMA models-LS approach, Model identification with ACF and PACF. Some classical algorithms for model building

MA4145 **2**
Design of Experiments
▷MA 2110, MA 2140

Linear Models, One-way and two-way classification models. Standard designs such as CRD, RBD, LSD, BIBD. Confounding. Fractional factorial deigns. A brief introduction to mixed effects models. Cross-over and cluster designs. Response surface methodology

MA4150 **2**
Homological Algebra II

Category Theory: Categories, Functors, Natural Transformations, Abelian Categories, Limits and Colimits, Adjoint Functors. Chain complexes, Homological Dimension, Spectral Sequences

MA4170 **1**
Linear Algebra Over Commutative Rings

Commutative rings, modules and their homomorphisms, sub-modules and quotient modules, tensor product

MA4210 **2**
Algebraic Curves and Integer Factorization

Ideals in polynomial rings, Hilbert's nullstellensatz, projective varieties, algebraic curves. elliptic curve in projective plane, integer factorization using elliptic curve

MA4220 **2**
Geometry of Complex Numbers

Holomorphic and meromorphic functions, compact Riemann surfaces, holomorphic maps, coverings, projective space and complex projective curves

MA4230 **2**
Advanced Calculus

Differentiation, integration, inverse function theorem, implicit function theorem, manifolds, differential forms, Stokes' theorem

MA4310 **3**
Topics in Number Theory

Basic congruences, division algorithm, quadratic reciprocity, Chinese remainder theorem, primitive roots, Fermat's little theorem, Pythagorean triplets, primality testing, arithmetic functions, prime number theorem, Riemann-zeta function

MA4320 **2**
Representation of Finite Groups

Representation of finite groups, complete reducibility, Schurs lemma, characters, projection formulae, induced representation, Frobenius reciprocity.

MA4610 **1**
Classical Results in Analysis and Applications
▷MA1110, MA1220

Implicit function theorem. Inverse function theorem. Stone-Weierstrauss theorem. Banach-Stone theorem. Arzela-Ascoli theorem. Mazur-Ulam theorem

MA4710 **1**
Topology and Its Applications

Topological spaces, quotient topology, separation axioms, connectedness and compactness. (If time permits:) Brief introduction to topological data analysis

MA5010 **3**
Combinatorics and Graph Theory

• Basic counting: Bijections, Counting objects with repetitions, de Bruijn-Erdos theorem, Listing combinatorial objects.
• Permutations: Combinatorial representation of a permutation, Descents and Eulerian polynomial, Tree representation for permutations.
• Inclusion-Exclusion principle: Use of Rook polynomial, Some arithmetic and Mobius functions.

• Parity: Parity in Graph theory, Eulerian circuits in graphs, digraphs and de Bruijn circuits, Hypercubes and Gray codes, Parity of a permutation, Quadratic reciprocity.
• Pigeonhole principle: Ramsey theorem, The infinite case.
• Geometry: Regular polytopes and tessellations of plane, triangulations and Sperner's lemma.
• Recurrence relations: Fibonacci recurrence relation, Linear homogeneous recurrence relations with constant coefficients, Case of repeated roots, Difference tables and sums of polynomials, Other types of recurrence relations.

MA5020 **3**
Functional Analysis
▷MA4010, MA4020

• Normed linear spaces. Non-compactness of the unit ball in infinite dimensional normed linear spaces. Product and quotient spaces. Banach spaces, Hilbert spaces.
• Linear maps. Boundedness and continuity. Linear isometries, linear functionals. Examples.
• Hahn-Banach extension theorem, applications. Banach-Steinhaus theorem, closed graph theorem, open mapping theorem and bounded inverse theorem, Spectrum of a bounded operator.
• Gram-Schmidt orthogonalization. Bessel's inequality, Riesz-Fisher theorem. Orthonormal basis, Parseval's identity, Projection, orthogonal decomposition. Bounded linear functionals on Hilbert spaces.

MA5030 **3**
Partial Differential Equations
▷MA4030

Basic Concepts: Definition and order of a PDE. Classification of PDEs. Examples of some important equations and their significance. Classification into hyperbolic, parabolic, and elliptic equations, Canonical forms.
First order PDE's: Method of characteristics (Charpit's method). Existence and uniqueness results for the Cauchy problem for quasilinear and fully non- linear equations. Breakdown of classical solutions.
Wave Equations: d'Alembert's formula, uniqueness and stability of solutions to the initial value problem for one dimensional wave equation. Parallelogram identity, domain of dependence, range of influence, finite speed of propagation, conservation of energy. Inhomogeneous equation. Duhamel's formula. Characteristic triangle. Spherical means, Hadamard's method of descent. Huygens' principle. Duhamel's principle for solutions of non-homogeneous wave equation. Uniqueness using energy method.
Laplace Equations: Green's identities, Uniqueness of solutions, Green's function and Possion's formula, Harnack's inequality, Liouville's theorem, Weak maximum principle, Mean-value property, Strong maximum principle, Analyticity of harmonic functions. Dirichlet principle, Uniqueness using energy method for Dirichlet, Neumann, and Robin(mixed) boundary value problems, Hadamard's example illustrating non-uniqueness, instability of solutions to Cauchy problem for Laplace equation.
Heat Equations: Fundamental solution, Cauchy problem for homogeneous heat equation, infinite speed of propagation, Duhamel's principle for non-homogeneous heat equation, Uniqueness using energy method for initial boundary value problem, Maximum principle and uniqueness, Ill-posedness of backward heat equation.
Supplementary Topic: Fourier Series Method: Construction of Fourier series solutions to Laplace, Heat, and Wave equations using method of separation of variables and their convergence.

MA5040 **3**
Topology

• Definition of Topologies in terms of open sets, neighborhood system, closed sets and closure operations and their equivalence, points of accumulation, interior, exterior and boundary points.
• Base and subbase of a topology, subspace, product space, quotient space, continuous, open and closed maps, homeomorphism convergence of sequence and nets.
• Separation axioms, Urysohn's Lemma, Tietze extension theorem, separability.
• Compactness, local compactness, sequential and countable compactness, Tychonoff's theorem, Lindelof space. One point compactification
• Connectedness and local connectedness.
• Urysohn's metrization theorem.

MA5050 **3**
Mathematical Methods

• Integral Transforms: Laplace transforms: Definitions - properties - Laplace transforms of some elementary functions - Convolution Theorem - Inverse Laplace transformation - Applications.
• Fourier transforms: Definitions - Properties - Fourier transforms of some elementary functions - Convolution theorems - Fourier transform as a limit of Fourier Series - Applications to PDE.
• Integral Equations: Volterra Integral Equations: Basic concepts - Relationship between Linear differential equations and Volterra integral equations - Resolvent Kernel of Volterra Integral equation - Solution of Integral equations by Resolvent Kernel - The Method of successive approximations - Convolution type equations, solution of integral differential equations with the aid of Laplace transformation.

• Fredholm Integral equations: Fredholm equations of the second kind, Fundamentals - Iterated Kernels, Constructing the resolvent Kernel with the aid of iterated Kernels - Integral equations with degenerate Kernels - Characteristic numbers and eigen functions, solution of homogeneous integral equations with degenerate Kernel - non homogeneous symmetric equations - Fredholm alternative.
• Calculus of Variations: Extrema of Functionals: The variation of a functional and its properties - Euler's equation - Field of extremals - sufficient conditions for the Extremum of a Functional conditional Extremum Moving boundary problems - Discontinuous problems - one sided variations - Ritz method.

MA5052 **3**
Advanced Mathematical Methods
▷MA4030, MA4060, MA 5050

Introduction: Ordering symbols, 'O and o' notation, Asymptotic Sequence, Asymptotic Analysis, Applications.

Basic Complex Analysis: Singularities of complex functions, Cauchy's residue and other important theorems, Jordan's lemma, Plemlj formulae.

Series Solution: Singular points – classification, Properties near ordinary and regular singular points, Frobenius solution for ordinary differential equations, Behaviour near irregular singular points, Method of dominant balance and some special functions: Airy functions, Gamma Function.

Matched Expansions, Boundary Layer Theory: Regular and singular perturbation theory, uniform approximations, Interior boundary layer analysis with examples. Generalised Functions: Introduction, derivatives of generalised functions, applications to singular integrals.

Integral Transforms: Fourier Transform, Laplace Transform, Mellin Transform, Riemann-Lebesgue Lemma and analytic continuation of Mellin Transforms.

Asymptotic Expansion of Integrals: Use of Mellin transform for asymptotic expansion of integrals, Laplace method, stationary phase, method of steepest and decent. Weiner-Hopf Method: Conformal mapping, critical points, Schwartz-Christoffel formula, Bilinear maps-Mobius transformation, Riemann-Hilbert problems and the Wiener-Hopf method.

MA5060 **3**
Numerical Analysis

• Floating point representation of numbers, floating point arithmetic, errors, propagation of error.
Solution of nonlinear equations: Iterative methods, Fixed point iteration method, convergence of fixed point iteration, Newton-Raphson method, complex roots and Muller's method.
Interpolation: Existence and uniqueness of interpolating polynomial, error of interpolation - interpolation of equally and unequally spaced data - Inverse interpolation - Hermite interpolation.
Approximation: Uniform approximation by polynomials, data fitting, Least square, uniform and Chebyshev approximations.
Solution of linear systems: Direct and iterative methods, ill-conditioned systems, Eigen values and eigen vectors: Power and Jacobi methods.
Integration: Newton-cotes closed type methods; particular cases, error analysis - Romberg integration, Gaussian quadrature; Legendre, Chebyshev formulae.
Solution of Ordinary differential equations: Initial value problems: Single step methods; Taylor's, Euler method, modified Euler method, Runge-Kutta methods, error analysis

MA5070 **3**
Modules and Fields

Review of Rings, Modules, Free modules, Cartesian products and direct sums of modules, quotient modules, Simple and semisimple modules, isomorphism theorems. Modules over principal ideal domains and applications. Noetherian and Artinian rings/Modules, Hilbert basis theorem. Jordan-Holder theorem. Projective/Injective modules.
Field extensions. Algebraic/transcendental elements, Algebraic extensions. Finite fields, Cyclotomic fields. Splitting field of a polynomial. Algebraic closure of a field, Uniqueness. Normal, separable, purely inseparable extensions. Primitive elements, simple extensions. Fundamental theorem of Galois theory. Solvability by radicals - Solutions of cubic and quartic polynomials, Insolvability of quintic and higher degree polynomials. Geometric constructions

MA5080 **3**
Advanced Programming

Mathematical background, Model - What to Analyze.
Abstract Data Types (ADT's), The List ADT, The Queue ADT, The Stack ADT, Preliminaries, Binary Trees, The Search Tree ADT, Binary Search Trees, AVL Tree, Preliminaries, Insertion Sort, Shell Sort, Merge Sort, Quick Sort, Definitions, Topological Sort and Minimal Spanning Tree.

MA5090 **3**
Sets, Logics and Boolean Algebra

Sets and Relations: Types of relations, Peano Axioms and Mathematical Induction, Cardinality, Recursion.
Boolean Algebra: Partially Ordered Sets, Lattices, Subalgebras, Direct Product,

Homomorphisms, Boolean Functions, Representation and Minimization of Boolean functions.
Mathematical Logic: Connectives, Normal Forms, Theory of Inference for the Statement Calculus.

MA5100 **3**
Introduction to Algebraic Topology
▷MA5040

Homotopy, Fundamental group, The Fundamental group of the circle, Retractions and fixed points, Application to the Fundamental Theorem of Algebra, The Borsuk-Ulam theorem, Homotopy equivalence and Deformation retractions, Fundamental group of a product of spaces, and Fundamental group the torus, Sphere, and the real projective n-space.
Free Products of Groups, The Van Kampen Theorem, Fundamental Group of a Wedge of Circles, Definition and construction of Cell Complexes, Application to Van Kampen Theorem to Cell Complexes, Statement of the Classification Theorem for Surfaces, Fundamental groups of the closed orientable surface of genus g.
Introduction to Covering spaces, Universal Cover and its existence, Unique Lifting Property, Galois Correspondence of covering spaces and their Fundamental Groups, Representing Covering Spaces by Permutations - Deck Transformations, Group Actions, Covering Space Actions, Normal or Regular Covering Spaces.

MA5110 **3**
Fourier Analysis and Applications
▷MA4010

• Definition, Examples, Uniqueness of Fourier series, Convolution, Cesaro summability and Abel summability of Fourier series, Mean square convergence of Fourier series, A continuous function with divergent Fourier series. Some applications of Fourier series, The isoperimetric inequality, Weyl's equidistribution theorem.
• Fourier transform on the real line and basic properties, The Schwartz space, Approximate identity using Gaussian kernel, Solution of heat equation, Fourier inversion formula, L^2-theory .
• Some basic theorems of Fourier Analysis, Poisson summation formula, Heisenberg uncertainty principle, Hardy's theorem, Paley-Wiener theorem, Wiener's theorem, Shannon sampling theorem.
• The class of test functions, Distributions, Convergence, differentiation and convolution of distributions, Tempered distributions, Fourier transform of a tempered distribution.

MA5120 **3**
Numerical Linear Algebra
▷MA4020

Gaussian elimination and its variants. Sensitivity of system of linear systems. QR factorization and The least squares. The singular value decomposition. Computing Eigenvalues and Eigenvectors. Iterative methods for linear systems.

MA5130 **3**
Theory of Computation

• Regular Languages: Finite Automata, Non-determinism, Regular Expressions, Nonregular Languages.
• Context-Free Languages: Context-free Grammars, Pushdown Automata, Non-context-free Languages
• The Church-Turing Thesis: Turing Machines and Variants.
• Decidability: Decidable Languages, The Halting Problem.
• Reducibility: Undecidable Problems, Example, Mapping Reducibility
• Time Complexity: Measuring Complexity, The classes of P and NP

MA5140 **3**
Mathematical Introduction to Elliptic Curves
▷MA4070

Plane curves, Bezout's theorem, Basic Theory of Elliptic Curves. Reduction modulo p, Torsion points. Elliptic curves over the complex numbers, Lattices and bases, Doubly periodic functions. Heights, Mordell-Weil theorem, rank of E(Q), Neron-Tate pairing, Nagell-Lutz Theorem, Elliptic curves over finite fields and local fields, Elliptic Curves and it's relation with modular forms.

MA5142 **3**
Elliptic Curve Cryptography
▷MA4060, MA4070

Elliptic curves, the group law, Weierstrass and Edwards curves, Efficient computation. Integer arithmetic, Finite field arithmetic.

The Discrete logarithm problem, the Index calculus, General attacks on discrete logs, Attacks with pairings, Anamalous curves, Diffie-Hellman key exchange, Massey-Omura encryption, ElGamal public key encryption, ElGamal digital signatures.

The Digital signature algorithm, Public key scheme based on factoring, A Cryptosystem based on the Weil pairing, Factoring using elliptic curves, Primality testing. The Weil and Tate-Lichtenbaum pairings, Miller's algorithm, Hyperelliptic curves, divisors, Cantor's algorithm

MA5150 **3**
Algebraic Number Theory
▷MA4070, MA5070

Localisation, Integral ring extensions, Dedekind domains, discrete valuation rings, unique factorisation of ideals, ideal class groups, finiteness of class number, some class number computations, valuations and completions of number fields, Hensel's lemma, norm, trace, discriminant, different, Ramification theory of p-adic fields, Decomposition groups, Inertia groups, cyclotomic fields, Gauss sums, quadratic reciprocity, geometry of numbers, Ostrowski's theorem, Dirichlet's unit theorem.

MA5160 **3**

Modular group, congruence subgroups, modular forms, examples, Eisenstein series,

An Introduction to Modular Forms
▷MA4060, MA4070

lattice functions, Some number theoretic applications, space of modular functions, expansions at infinity, zeroes and poles using contour integrals, Hecke operators, Theta functions, Atkin-Lehner theory, Petersson inner product, Eigenforms, L-functions and some properties, relation between Modular forms and Elliptic curves.

MA5170 3
Basic Introduction to Algebraic Geometry
▷MA4070, MA5070

Algebraic curves in the plane, Singular points and tangent lines, local rings, intersection multiplicities, Bezout's theorem for plane curves, Max Noether's theorem and some of its applications. Affine spaces, Projective spaces, Affine and projective varieties, coordinate rings, morphisms and rational maps, local ring of a point, function fields, dimension of a variety, Zariski's main theorem.

MA5180 3
Advanced Measure Theory
▷MA5030

• Revision on Radon-Nikodym Theorem, Radon-Nikodym derivative and their applications.
• Complex measure and its various properties, Complex analogue of Radon-Nikodym
• Theorem. Dual of $C^0(X)$, the space of all complex valued continuous functions vanishing at infinity on a locally compact Hausdorff X.
• A revision on the spaces $L^p(\mu)$ for a σ finite measure μ. Dual of $L^p(\mu)$. Dense subclasses of $L^p(\mu)$.
• Modes of convergence: pointwise convergence, convergence in measure, convergence almost uniformly. Egoroff's Theorem.
• Fundamental Theorem of Calculus for Lebesgue Integrals. Derivative of an integral.
• Derivative of a measure: The Lebesgue Differentiation Theorem. Functions of Bounded Variation and Rectifiable curves in the plane. Absolutely continuous functions.

MA5190 3
Advanced Partial Differential Equations
▷MA4080, MA5030

Review: Quasi-linear PDE, Cauchy problem, higher order PDE, classification, wave equation, heat equation, Laplace equation.
Introduction to non-linear waves: 1-D linear equation, basic non-linear equations, expansion wave, centered expansion wave, breaking and examples. Shock waves, discontinuous shocks, equal area rule, asymptotic behavior, shock structure, Burgers equation, Thomas equation.
Second order systems: the equations of shallow water theory, method of characteristics, waves on a sloping beach, linear and nonlinear theory, conservation equations and boundary value problems,, exact solutions for certain nonlinear equations.

MA5220 3
Applied Functional Analysis

Review of normed linear spaces, Banach and Hilbert spaces. Orthogonal systems in Hilbert spaces, Representation through harmonic and nonharmonic bases, Redundant representations, Sampling theorems, Issues with under-sampling and over-sampling, Applications in signal analysis

MA6010 3
Topics in Analysis

Real Analysis: Review of real numbers, sequences and series.
Basic topology, continuity, differentiation, Riemann-Stieltjes integral, Sequence and series of functions.
Complex Analysis: Analytic functions, Harmonic conjugates, Cauchy theorems and consequences, Power series, Maximum modulus theorem, Phragmen Lindelof theorem, Singularities, Laurent series, Residues. Mobius transformations.

MA6020 3
Topics in Algebra

Review of vector spaces, bases, dimension, Linear transformations, The rational and Jordan forms, Inner product spaces, Bilinear forms.
Review of Group Theory, Jordan Holder theorem, Rings, Modules and Fields.

MA6040 3
Fuzzy Logic Connectives and Their Applications

Fuzzy Logic Connectives: T-norms : Classes and their generation process, Algebraic and analytical properties, related conjunctions.
Fuzzy implications: Classes and their generation process, Algebraic and analytical properties.
Fuzzy Measures and Integrals: An Introduction.
Applications: Including but not limited to :Approximate Reasoning, Clustering and Data Analysis, Image Processing

MA6050 3
Wavelets and Applications

Fourier transform - Continuous wavelet transform, frames - Multiresolution analysis, discrete wavelets, - Spline, orthogonal and biorthogonal wavelets - Applications in Image processing, Numerical analysis

MA6060 3
Redundant and Sparse Representation Theory

Redundant representations, Orthogonal, nonorthogonal and frame type bases, Sparsity, Coherence, Uncertainty Principle , L1 minimization, Probabilistic and deterministic approaches, Convex and iterative methods, Applications in analog-to-digital conversion, Nyquist sampling theory, Low-rank matrix recovery, Dictionary design, Recent develop

MA6070 3
Approximation Theory

The Theorems of Weierstrass, Bernstein, Fejer, and Korovkin, Stone's Approximation Theorem and the Stone-Weierstrass Theorem, Some applications, Best approximation in normed spaces: some basic notions and results, Degree of uniform approximation by algebraic and trigonometric polynomials - Modulus of continuity and modulii of

smoothness - Jackson's theorems - Bernstein's inequality for trigonometric polynomials - Inverse theorems for uniform trigonometric approximation, Bernstein and Markov inequalities for algebraic polynomials, Characterizations of best uniform approximants - Theorems of Collatz and Schewdt, Collatz and Kolmogorov - Haar systems and the Haar-Kolmogorov Theorems - Chebyshev's Alternation Theorem and some applications.

MA6080 **3**
Measure Theoretic Probability

Classical Probability and Preliminaries: Discrete Probability, Conditional Probability, Expectation, Theorems on Bernoulli Trials. Basic definitions of algebraic structures, few facts about Banach Spaces; Measure Theory: Sigma Algebra, Measurable functions, Positive and Vector valued measures, Total Variation of a measure, Spaces of measures, Lebesgue Measure on R, Completion, Caratheodory's theorem, • Lebesgue Integration: Abstract Integral, Convergence theorems of Lebesgue and Levi, Fatou's Lemma, Radon-Nikodym Theorem, Modes of convergence of measurable functions; Product Spaces: Finite Products, Fubini's Theorem, Infinite Products, Kolmogorov's Extension Theorem; Independence: Random Variables, Distributions, Independent Random Variables, Weak and Strong Law of Large Numbers, Applications.

MA6090 **3**
Operator Theory

Operators on Hilbert spaces: Basics of Hilbert spaces; Bounded linear operators, Adjoint of operators between Hilbert spaces; Self-adjoint, normal and unitary operators; Numerical range and numerical radius; compact operators, Hilbert-Schmidt operators. Spectral results for Hilbert space operators: Eigen spectrum, approximate eigen spectrum; Spectrum and resolvent; Spectral radius formula; Spectral mapping theorem; Riesz-Schauder theory; Spectral results for normal, self-adjoint and unitary operators; Functions of self-adjoint operators. Spectral representation of operators: Spectral theorem and singular value representation for compact self-adjoint operators; Spectral theorem for self-adjoint operators. Unbounded Operators: Basics of unbounded closed Operators in Hilbert spaces, Cayley transform, Spectral theorem for unbounded self-adjoint operators.

MA6100 **3**
Mathematics Behind Machine Learning

Data Representation: Eigenvalues - Eigenvectors - PCA - SVD - Fischer Discriminant; Functionals - Hilbert Spaces - Riesz Representation Theorem - Kernel Trick - Kernel PCA - Kernel SVM; Norm Minimization - LLE - Sparse Representation Theory - Dimensionality Reduction
Supervised Learning: Convex Optimisation - Primal-Dual Transformations - Karush-Kuhn-Tucker Conditions - SVM; Probability and Measures - Types of Convergences - Statistical Learning Theory - VC dimension and Capacity - Some bounds
Unsupervised Learning: Expectation Maximization - EM-based Clustering - C-means clustering - Fuzzy CM clustering; Operator Theory - Decomposition of Operators and Subspaces - Subspace Clustering

MA6110 **3**
Convex Functions and Their Applications

Basic properties of convex functions; Convex functions on a normed linear spaces; Various notions of differentiability of a convex function on a normed linear space; Monotone operators, Asplund spaces and Radon Nikodym property; A smooth variational principle and more on Asplund spaces.

MA6116 **3**
Commutative Algebra
▷MA 4070

Modules, ideals, prime ideals, maximal ideals. Noetherian rings; Hilbert basis theorem. Minimal primes. Localization. Polynomial rings and algebraic sets. Weak Nullstellensatz. Nilradical and Jacobson radical; strong Nullstellensatz. Integral extensions. Prime ideals in integral extensions. Noether Normalization Lemma. Krull dimension; dimension of an affine algebra.

MA6120 **3**
An Introduction to Operator Algebras

Banach Algebras: Banach Algebras and invertible group; spectrum; multiplicative linear functionals; Gelfand transform and applications; maximal ideal spaces; Non-unital Banach Algebras.
C*-algebras: C*-algebras; commutative C*-algebras; the spectral theorem and applications; polar decomposition; positive linear functional and states; The GNS Construction; non unital C*-algebras
von Neumann Algebras: Topologies on B(H); Existence of projections; the Double Commutant Theorem; the Kaplansky density theorem; the Borel functional calculus; Abelian von Neumann algebras; the La functional Calculus; equivalence projections; Type decompositions

MA6126 **2**
Combinatorial Commutative Algebra
▷MA 4070

Monomial ideals and simplicial complexes. The theory of Gröbner bases. Hilbert functions. Resolutions of monomial ideals. Multigraded Betti numbers. Cellular resolutions. Alexander duality. Toric varieties and lattice ideals.

MA6130 **3**
Banach Space Theory

Basic properties of Banach spaces; Classical Banach spaces and their various properties; Linear operators in Banach spaces; Schauder bases; Convexity and smoothness.

MA6140 **3**
Compressive Sensing

Nyquist Sampling Theorem, Under-determined linear systems, Classical solution techniques, l0, l1 and l2 norm minimization problems, Theoretical guarantees for sparse recovery, Greedy and Convex optimization techniques, Dictionary Learning, Applications in Signal Processing.

MA6150 **3**
Discrete Dynamical Systems
▷MA4010, MA4060, MA5040

Phase portraits, Topology of the Real numbers, periodic points and stable sets, Sarkovskii's theorem, Families of dynamical systems, bifurcation, The logistic function, Cantor sets and chaos, topological conjugacy. period-doubling cascade. Symbolic dynamics. Newton's method. Complex dynamics, quadratic family, Julia sets, Mandelbrot set.

MA6160 **3**
Banach Algebras
▷MA4010, MA4020, MA4060, MA5020, MA5040

Preliminaries on functional analysis, Banach spaces and Hilbert spaces.
Banach algebras: Definition, homomorphism, spectrum, basic properties of spectra, Gelfand-Mazur theorem, spectral mapping theorem, group of invertible elements.
Commutative Banach algebras and Gelfand theory: Ideals, maximal ideals and homomorphism, semi-simple Banach algebra, Gelfand topology, Gelfand transform, involutions.
Banach*-algebras, Gelfand-Naimark theorem, applications to non-commutative Banach algebras. A characterization of Banach*-algebras.

MA6170 **3**
Topics in Differential Equations

• Ordinary Differential Equations: Existence and uniqueness of solutions of first order ODE, system of first order equations and the nth order ODE. The method of successive approximations.
• Variations of solutions with respect to initial conditions and parameters. Linear Differential equations and asymptotic behaviour of the solutions of certain linear systems problem.
• Linear systems with isolated singularities: Singularities of the first kind and singularities of the second kind.
• Partial Differential Equations:
• First order PDE: Pfaffian differential equation, Quasi-linear PDE's, Cauchy Problem, Compatible systems, non-linear PDE's, Monge Cone Method.
• Higher order PDE: Classification, canonical form, Heat equation, Wave equation, Laplace equation, Uniqueness theorems.

MA6180 **3**
Topics in Computational Mathematics

• Basics of Programming: Structure of a Program - Variables and Data Types - Conditional Statements -Loops - Functions - Arrays.
• Boolean Logic:
• Propositional Logic: Syntax of PL - Semantics of PL - Normal Forms - Some Applications - Resolution Proof Procedure - Proofs in PL - Axiomatic System of Predicate Calculus - Soundness and Completeness of PL
• First Order Logic: Syntax and Semantics - Proofs in FL - Axiomatic System of First Order Calculus - Soundness and Completeness of FL
• Recurrence Relations: Growth of Functions - Asymptotic Notations - The Substitution Method - The Recursion-Tree Method - The Master Method.

MA6190 **3**
Transcendental Number Theory
▷MA4010, MA4060, MA4070, MA5070.

Irrational Numbers: Decimal representation of real numbers, repeating decimals and rational numbers, irrationality of k-th root of an integer, irrationality of e, π, irrationality of various trigonometric functions at rational arguments, irrationality of $\zeta(3)$.
Transcendental Numbers: Liouville's construction of transcendental numbers, transcendence of e and π, Lindemann's theorem on algebraic independence of exponentials of algebraic numbers and its corollaries, Gelfond - Schneider theorem on transcendence of algebraic exponents of algebraic numbers and its corollaries, linear forms in logarithms - Baker's theorem with application to the Catalan's conjecture, Mahler's construction of transcendental numbers.

MA6210 **3**
Curves and Surfaces

Curves in two and three dimensions, curvature and torsion for space curves, Serret-Frenet formula for space curves, Surfaces in R3, Tangent spaces and derivatives of maps between manifolds, geodesics, first fundamental form, orientation of a surface, Second fundamental form and the Gauss map

MA6220 **3**
Distribution Theory and Sobolev Spaces

Distributions: Test functions and Distributions, Convolution of Distributions, Fundamental solutions, The Fourier transforms, The Schwartz space $\mathscr{S}$, Tempered Distributions.
Sobolev spaces: Definition and basic properties, Approximations by smooth functions, Traces, Sobolev inequalities, Compactness, Other spaces of functions, Dual spaces, Fractional order spaces and trace spaces.
Weak solutions of elliptic boundary value problems: Definitions of weak solutions, Existence, The Lax-Milgram theorem, Regularity, Galerkin method, Maximum principle, eigenvalue problems, Introduction to finite element methods.

MA6230 **3**
An Introduction to Variational Methods

Preliminaries: Differential calculus, The local and the global inversion theorems, Function spaces, Nemitski operators, Elliptic equations.
Topological methods: Bifurcation results, The Lyapnov-Schmidt reduction, Bifurcation from the simple eigenvalue. Brouwer degree and its properties, The LeraySchauder degree, Some applications to elliptic equations, The Krasnoselski bifurcation theorem, The Rabinowitz global bifurcation theorem.
Critical points and extrema: Functionals and critical points, Gradients, Existence of extrema, Differentiable manifolds, an outline, Constrained critical points, Manifolds of codimension one, Natural constraints.
Deformations and the PalaisSmale condition: Deformations of sublevels, The steepest descent flow, The PalaisSmale condition, Existence of constrained minima, The mountain pass theorem, Applications.

MA6240 **3**
Differential Geometry

Differentiable manifolds, Tensor fields, Differential forms, Riemannian metrics and induced metrics on tensor bundles, Connections and covariant differentiation, Geodesics and Curvature.

MA6260 **3**
Algebraic Geometry I

Sheaves, Schemes and morphisms, First properties of schemes, Finiteness conditions on morphisms, Separated and proper morphisms, Sheaves of modules, Coherent sheaves, Divisors, Projective morphisms, Blowing up, Differentials, Tangent and normal bundles.

MA6270 **3**
Algebraic Geometry II

Derived Functors, Cohomology of sheaves, Cohomology of noetherian affine schemes, Cech cohomology, Cohomology of projective space, Ext groups and sheaves, Serre duality theorem, Higher direct images of sheaves, Flat morphisms, Smooth morphisms.

14.13 Department of Mechanical and Aerospace Engineering

AE3010 **1.5**
Introduction to Aerospace Vehicles

- History of Aviation
- Pre Wright brothers, up to World War II, post World War II, space age
- Key people in the history of aerospace engineering and their contribution
- Classification of aerospace vehicles and their characteristics
- Civilian aircrafts, military aircrafts, fighters, bombers, reconnaissance
- AWACS, helicopters, gliders, launch vehicles, satellites, UAVs
- Missiles: SAM, AAM, anti-tank, cruise missiles, strategic missiles
- Key aerospace companies in the current scenario
- Future of Aerospace vehicles

AE3020 **3**
Aerodynamics
▷ID1100, ID1140, AE3010

- Inviscid aerodynamics
- Subsonic, transonic, and supersonic airfoil theory
- Wing theory
- Introduction to compressible flow
- Normal and oblique shock waves
- Prandtl-Meyer expansions
- Linearized compressible flow
- Hypersonic aerodynamics
- Computational aerodynamics methods

AE3030 **1.5**
Flight Mechanics

- Introduction to flight instruments and earth's atmosphere
- Characteristics of aerospace vehicles
- Case study of some of the popular aerospace vehicles
- Basic aerodynamics, generation of lift/drag. Airfoils and finite wings. Elements of aircraft performance and atmospheric flight mechanics. Introduction to aircraft design, stability and control.

AE3040 **3**
Aerospace Structures
▷ID1160, ID2020, AE3010

- Basic equations of linear elasticity: Concept of stress and strain, Constitutive behavior of materials, Two-dimensional problems in elasticity.
- Aircraft structures and materials: Basic structural elements in aircraft structure, Loads on the aircraft, Aircraft materials
- Beams and thin walled structures: Three-dimensional beam theory, Torsion of bars with arbitrary cross-section, Bending of thin walled beams, Shear center, Torsion of thin walled beams, Warping of thin walled beams.
- Plates: Kirchhoff plate theory, Bending and buckling of plates
- Introduction to Aeroelasticity: Wing divergence and flutter calculations.

AE3050 **1.5**
Aircraft Propulsion
▷ID1140, AE3010

- Basic one-dimensional flows: isentropic area change, heat addition
- Overall performance characteristics of propellers, ramjets, turbojets, turbofans, rockets
- Performance analysis of inlets, exhaust nozzles, compressors, burners, and turbines

AE3070 **1.5**
Rocket Propulsion
▷ID1140, AE3010

- Rocket flight performance,
- Single-/multi-stage chemical rockets,
- Solid propellants
- Liquid propellants
- Cryogenic engines
- Advanced propulsion concepts

ME1010 **1**
Manufacturing Technology

Introduction to Product Design, Introduction to manufacturing, Evolution of manufacturing. Engineering Materials and their selection, Classification of Manufacturing Processes: Formative Processes (Molding Processes, Deformation Processes), Additive Processes (Joining and Rapid Prototyping Processes), Removal Processes (machining, non-conventional), Introduction to Measurements, Machine Tools and Data Communication, Importance of Integrated Design and Manufacturing.

ME1030 **2**
Dynamics
▷ID1130

Kinematics of particles - Rectilinear motion of particles, curvilinear motion of particles, Kinematics of rigid bodies, Kinetics of particles, system of particles, plan motion of rigid bodies, energy and momentum methods, kinetics of rigid bodies in three dimensions, and introduction to mechanical vibrations.

ME2030 **2**
Manufacturing Science -I
▷ME1010

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.

ME2040 **1.5**
Instrumentation

Introduction to measurements, various principles of measurements, errors in measurement, basic statistics, calibration procedures, displacement measurement, measurement of temperature, measurement of pressure, measurement of fluid flow, obstruction meters, measurement of fluid velocities, thermal anemometry, strain gauges, measurement of force, torque and power, load cells, torque cells, dynamometers, vibration measurement, velocity and acceleration measurement.

ME2080 **1**
Introduction to Mathematical Modelling
▷MA1110, MA1220, MA1130, MA1140, MA1150

Introduction to mathematical modelling, introduction to symbolic and numerical computation, degrees of freedom, modelling in dependent and independent coordinates, lagrange equations, and numerical solution of mathematical models.

ME2090 **2**
Kinematics of Mechanisms
▷ID1130, ME1030

None

ME2100 **2**
Dynamics of Mechanisms
▷ID1130, ME1030

Dynamics of rigid body in a plane; static and dynamic force analysis of machines; balancing of rotating masses; balancing of reciprocating masses - single and multi-cylinder engines; turning moment diagram, flywheel analysis; free and forced vibration of single degree of freedom systems - resonance, vibration isolation

ME2421 **1**
Solid Mechanics Lab
▷ID2020

Solid Mechanics: Torsion testing, UTM-tensile testing, thin cylinder behavior, buckling of struts, deflection of beams, spring stiffness, impact testing and hardness testing.

ME2431 **1**
Fluid Mechanics Lab
▷ID1100

Fluid Mechanics: Measurement of fluid properties: density, specific gravity and viscosity, surface tension; Measurement of pressure: Manometers, Bourdon pressure gauge; Measurement of discharge coefficient: Venturi meter, Orifice meter, Rota meter and V/Rectangular notches; Friction loss coefficients in pipe flows: Impact of water jet and stability of floating bodies; channel flow.

ME3010 **2**
Manufacturing Science - II
▷ME1010

Conventional Removal and Finishing Processes: Importance of Material Removal and allied processes, classification; Chip Formation; Types of Chips; Tool Specification: Coordinate and Orthogonal Systems; Mechanics of Metal Cutting: Merchant's Circle Diagram, Stress, Strain and Strain Rate, determination of Shear Plane Angle; Tool Wear and Tool Life; Variables affecting Tool Life; Practical Machining Operations: Turning, drilling, milling; Finishing Operations: Grinding (MRR estimation, Wheel Specifications, Wheel Wear) and other processes; Economics of machining: Minimum Production Cost Criterion, Maximum Production Rate and Maximum Profit Rate Criteria; Unconventional Removal and Finishing Processes: Abrasive Jet Machining, Ultrasonic Machining; Electro Discharge Machining; Abrasive Jet Machining; Electron Beam Machining; Laser Beam Machining, Finishing processes (AFM and other variants); Micro-Manufacturing and Scaling Laws: Miniaturization and its importance, Micro-Manufacturing Processes (Additive, formative and Removal), Scaling laws with emphasis on micro-Manufacturing.

ME3040 **1.5**
Mathematical Elements for Geometrical Modeling

Introduction to computer aided design, fundamentals of computer graphics; geometric modelling of synthetic curves: Hermite, Bezier, B-spline, NURBS. Parametric representation of surfaces: plane, ruled, revolution; Part modelling techniques: wireframe, surface and solid modelling, data representation and exchange formats, geometry and topology. Three-dimensional transformations and projections.

ME3050 **1.5**
Computer Integrated Manufacturing
▷ME3040, ME2030, ME3010

Current developments in CAD- feature based modeling, design by feature, function, feature linkages, application of feature based models, parametric modeling; Computer Aided Manufacturing: fundamentals of part programming, path generation, post processing and verification; Group Technology, Computer aided process planning (CAPP), computer aided inspection and reverse engineering, manufacturing process simulation, virtual and distributed manufacturing, computer integrated manufacturing.

ME3060 **1**
Experimental Testing Techniques
▷ID1100, ID1160

Basics of statistics. Determining the sample size, hypothesis testing and confidence intervals. Design of experiments, curve fitting and regression analysis, error analysis, practical aspects to documenting, interpreting and reporting experimental data. Data Acquisition and Processing. Data interpretation using graphical tools. Case studies.

ME3070 **1.5**
Power and Refrigeration System

Power and Refrigeration Systems -Gaseous Working Fluids: The Brayton Cycle, The Simple Gas-Turbine Cycle with a Regenerator, Gas-Turbine Power Cycle Configurations, The Air-Standard Refrigeration Cycle, Reciprocating Engine Power Cycles, Combined-Cycle Power and Refrigeration Systems
Gas Mixtures: A Simplified Model of a Mixture Involving Gases and a Vapor, the Energy Equation Applied to Gas-Vapor Mixtures, the Adiabatic Saturation Process, Wet-Bulb and Dry-Bulb Temperatures and the Psychrometric Chart
Thermodynamic Relations: The Clapeyron Equation, Mathematical Relations for a Homogeneous Phase, The Maxwell Relations, Thermodynamic Relations Involving Enthalpy, Internal Energy, and Entropy, Volume Expansivity and Isothermal and Adiabatic Compressibility, Real-Gas Behavior and Equations of State, The Generalized Chart for Changes of Enthalpy at Constant Temperature, The Generalized Chart for Changes of Entropy at Constant Temperature, The Property Relation for Mixtures, Pseudo-pure Substance Models for Real Gas Mixtures, Engineering Applications—Thermodynamic Tables
Chemical Reactions: Fuels, The Combustion Process, Enthalpy of Formation, Energy Analysis of Reacting Systems, Enthalpy and Internal Energy of Combustion; Heat of Reaction, Adiabatic Flame Temperature, The Third Law of Thermodynamics and Absolute Entropy, Second-Law Analysis of Reacting Systems, Fuel Cells, Engineering Applications
Introduction to Phase and Chemical Equilibrium: Requirements for Equilibrium, Equilibrium Between Two Phases of a Pure Substance, Metastable Equilibrium, Chemical Equilibrium, Simultaneous Reactions, Coal Gasification, Ionization, Engineering Applications

ME3080 **2**
Design of Machine Elements
▷ID2020

Design consideration - limits, fits, tolerances, and standardization, a brief introduction to strength of materials, modes of failure, failure theories, design of springs - helical, compression, tension, torsional and leaf springs, design of joints - threaded fasteners, preloaded bolt joints, welded and glued joints.

ME3090 **2**
Design of Transmission Elements
▷ID2020

Design of shafts under static and fatigue loading, shaft components. Design and analysis of sliding and rolling contact bearings, analysis and applications of power screws and couplings, analysis of clutches and brakes, design of belt and chain drives, design of spur and helical gears.

ME3100 **2**
Modeling and Simulation

Introduction to modelling and simulation, introduction to symbolic and numerical computations, degrees of freedom, modelling in dependent and independent coordinates,

▷ME2080	Lagrange equations, state space formulation, Newton-Raphson method, explicit integrator, implicit integrator, dynamics of constrained mechanical systems as differential algebraic equations, Baumgaurte stabilization, Gauss principle, and inverse problems.
ME3110 **3** Heat and Mass Transfer ▷ID1110, ID1150	Introduction - Steady State heat conduction in one-dimensional systems. One dimensional unsteady state conduction; extended surface heat transfer (Fins). Convection: Basic equations, Dimensional analysis, Boundary layers; Forced convection: External and internal flows, correlations, Natural convection and Mixed convection. Design of heat exchangers: LMTD and NTU methods. Radiation heat transfer: Basic laws, Properties of surfaces, view factors, network method and enclosure analysis for gray-diffuse enclosures containing transparent media. Concepts of Mass transfer. Current trends of research in the field of heat transfer.
ME3140 **3** IC Engines	Classification, Basic Working Principles, Components and Engine Operating Events of an IC Engine; Engine Operating Parameters: Geometry, Torque, Power and Work; Fuel Consumption and Efficiencies; Thermochemistry for IC Engines: Fuels and Testing; Combustion Reactions; Combustion Efficiencies; Chemical Kinetics and Exhaust Gas Analysis; Engine Cycle Models: Basic Thermodynamic Analysis; Air Standard Cycles; Fuel-Air Standard Cycles; Comparisons to Real Engines Cycles; Intake Flow Considerations: Gas Flow Processes; Valve Design; Fuel Induction Processes for SI and CI Engines; Combustion Chamber Considerations: In-cylinder Aerodynamics; Burning Process for SI and CI Engines; Abnormal combustion in SI Engines (Knock); Pollutant Formation and Control: Emission Measurement; NOx, CO, Unburned Hydrocarbon, Particulates, formation and their control.
ME3150 **2** Applied Elasticity ▷ID2020	Introductory tensor analysis, various strain measures and stress tensors, Balance laws, constitutive relations (commonly used energy density functions), special cases through simplification (incompressibility, plane stress and strain, hydrostatic loading, isotropy, linear elasticity), problems in Cartesian and other curvilinear coordinates. Introduction to FEM.
ME3413 **2** Machine Drawing and Solid Modelling ▷ID1041, ID1054	Principle of drawing. Introduction to machine drawing, production drawing, assembly drawing. Different sectional views. Fits, limits, tolerances and surface finish. Solid modelling of different machine elements. Example, threads, bolts, and nuts, welded and riveted joints, shafts, keys, cotter, and pin joints; couplings and clutches, springs, belts, and pulleys; bearings, gears. Assembly of different components of IC engine.
ME3425 **3** Mini-project	Objective: To direct students toward the process of designing and development through visualization, planning and manufacturing of a product leading to 'Invention and Innovation'. Deliverables: Visualize, Draw, Build, Improve, Modify, Identify, Suggest. Constituents: Concept, Design (Mechanical, thermal, chemical), Drawing (2D/3D manufacturing details), Manufacturing, Testing, Simulation.
ME3445 **1** Finite Element Methods Lab ▷ID2020	Finite element methods for solving boundary value problems in solid mechanics. Introduction, Spatial Modelling, Geometric discretization, Element Library, Material Modelling, Loading and Boundary Conditions, Constraints, Surface/Interfaces modelling, Step and job handling and Post-processing. FEA Implementation and Visualization of 1D Problems, Truss Problem, Beam bending, Plane and axisymmetric Problems and 3D problems. Various analysis such as, Static, Transient, Harmonic, Modal, Dynamics and Multi Physics (Thermomechanical, etc).
ME3455 **1** Computational Fluid Dynamics Lab	CFD mesh generation techniques, CFD experiments using commercial code - boundary layer flow, convective heat transfer, turbulent mixing and heat transfer, at least one analysis on an advanced topic like multiphase flow, combustion, turbo-machines.
ME3465 **1** Manufacturing Lab	Job preparation using CNC machining, Robotic welding, 3D printing, EDM, Injection molding. Measurements of parts using CMM; Form measurement; Digitization using 3D scanner, surface roughness testing. Deep drawing using forming machine. Cutting force measurement using dynamometer. Sample preparation and characterization using Optical Microscope.
ME3475 **1** IC Engines Lab	Objective: Experimental exposure to testing performance of IC engines at varying operating conditions. Experiment list: Components of an IC engine - CI and SI types; Testing and performance of IC engines by varying speed, load, compression ratio and other parameters. Study of Valve Timing Diagram.
ME4010 **1.5** Control Systems ▷MA2130	Concept of control, modeling physical systems, Laplace transforms and transfer function, block diagrams, Routh's stability criterion, transient and steady state response specification, root locus analysis, lead, lag, and lead-lag compensator design through root

locus - P, PI, PD, and PID controllers.

ME4020 **3**
Turbo Machines
▷ID1110, ID1150
Axial and radial flow turbomachines; Basic Principles; Dimensional Analysis; Two-dimensional cascades; Axial flow turbines; Axial flow compressors and ducted fans; Centrifugal pumps, Fans, compressors; Radial flow gas turbines; Hydraulic turbines.

ME4030 **1**
Operations Research
Basics of probability and statistics, Linear Programming and applications, Queuing theory and its applications, forecasting approaches, Monte Carlo simulation procedure (OR). Inventory models discussion (deterministic and probabilistic Models), Newsvendor model, Inventory Planning and Control, Decision support system tools, Economic Order Quantity (EOQ).

ME4040 **1**
Industrial Engineering
Product Design: Design for Manufacture and Assembly (DFM), Concurrent engineering Work systems design: Work study and classifications, Method study - work measurement, work sampling, Cost Estimation, Calculation of Machining Times, Cost Depreciation, Productivity, Productivity Measurement, Time study, Recording Techniques for Work Study, Information Collection Techniques, Job Evaluation, Ranking system, Incentive Schemes, Individual-Group-Company-wide Bonus Schemes, Behavioural aspects of Incentives Plant layout, Ergonomics, CRAFT, Cellular Manufacturing, Scheduling, Assembly Line Balancing, Future directions in Production.

ME4050 **1**
Production Planning and Control
Quality management and control: Quality Improvement, Cost of Quality, Statistical Process Control, Central Tendency and Dispersion, Control Charts, Acceptance Sampling, New Quality Concepts, Taguchi Methods, Design of Experiments (DoE), Robust Design, Ishikawa Diagram, ISO certification, Kaizen, Zero Defects Program, Total Quality Management (TQM), Six Sigma; Maintenance Management: Preventive and breakdown maintenance approaches, reliability, Work study for Maintenance, Total Productive Maintenance (TPM), Spare Parts Management, Characteristics and classification of Spare parts; Supply Chain design, scheduling, layout design: Materials Requirement Planning (MRP), MRP-II, Enterprise Resource Planning (ERP), Logistic, Distribution and Supply chain Management, Applications of Newsvendor model in supply chains.

ME4325 **3**
Elective Project
Optional elective project for seventh semester Btech students

ME4435 **1**
Dynamics Lab
▷ME2090, ME2100
Gear Efficiency Measurement, Planar Mechanism Demonstration, Rotary Balancing, Reciprocating Balancing, Static and Dynamic Analysis of Cam, Whirling of Shaft, Governors, Moment of Inertia Measurement.

ME4445 **1**
Heat Transfer Lab
▷ME3110
Heat Transfer: Temperature measurement and calibration; Measurement of thermal conductivity: solids and liquids; Heat exchangers: Concentric tube, shell and tube; Measurement of convective heat transfer coefficient: Free and Forced convection; Measurement of emissivity; Pool boiling and Condensation.

ME5935 **5**
Dual Degree Thesis (stage-1)
Dual Degree Thesis (Stage-1) for Dual Degree (BTech + MTech) students

ME5945 **18**
Dual Degree Thesis (stage-2)
Dual Degree Thesis (Stage-2) for Dual Degree (BTech + MTech) students

ME5955 **22**
Dual Degree Thesis (stage-3)
Dual Degree Thesis (Stage-3) for Dual Degree (BTech + MTech) students

14.14 Department of Materials Science and Metallurgical Engineering

MS1010 **1**
Science and Engineering of Materials
Introduction to general concepts of metallurgy and materials science and general considerations in application orientated material design - through three example case studies on bone, sensors, and defence materials, Types of materials (metals, ceramics, polymers, hybrids), general material properties (structural and functional), trade off in material properties and brief introduction to optimisation, followed by classroom discussion sessions. Overall, the course offers a wide vision on how materials have led to technological advancement in all aspects and is designed to help appreciate the courses in following semesters.

MS1020 **1**
Structure of metals, Determination of structure and chemical composition, concepts of

Metallic Materials	alloys, phase and phase diagrams
MS1030 **1** Materials Characterization I	Introduction to waves and EM waves - Introduction to spectroscopy - oscillators in molecules and solids - selection rules - types of spectroscopy - Vibrational (IR/Raman) and Absorption spectroscopy.
MS1040 **1** Materials Synthesis	Introduction to chemical synthesis of ceramic materials by solution based approaches- co-precipitation, sol-gel, hydrothermal, sonochemical. Vapour phase synthesis -PVD, CVD, molecular beam epitaxy etc. Solid State route- solid state reaction basics, combustion synthesis
MS1050 **1** Physics of Solids	Atomic structure - Chemical bonding - Types of bonds - Metals - Fermi level - Fermi surface - Crystal structure - Bravais lattice - Atomic stacking - Reciprocal lattice - Kroenig Penning model - Band formation - Material classification
MS1060 **1** Polymers	Introduction to polymers- synthetic and natural, structure (states and configuration) of polymers, synthesis, effect of temperature (glass transition and melting), branching, cross-linking on properties, structure - properties relationship and application, processing techniques and product development
MS1070 **1** Semiconductor Materials	Semiconductor crystals - Band formation in semiconductors - Direct and Indirect Band gap semiconductors - Concept of holes - Hall Effect - Effective mass - heavy and light mass carriers - Doping in semiconductors - Band bending - Heavily doped semiconductors - Excitons
MS1080 **1** Computational Methods in Materials Science I	Length scales in materials - macro to electronic structure; overview of modeling techniques at different length and time scales; concepts of linear algebra and matrix computation; Introduction to Mathematica® - symbolic and numeric calculations, basic plotting and visualization, roots of equations.
MS1090 **1** Micromechanics of Solids	Concepts of scalar, vectors, matrix and tensor; Cartesian tensors; Vector and tensor algebra; Deformation - displacement and strain; Stress and mechanical equilibrium; Concepts of linear elastic solids.
MS2010 **1** Soft Matter Science	Colloids, foams, gels, surfactants soft biological materials such as DNA, liquid crystals - structure, property, characterisation and applications, theoretical concepts
MS2020 **2** Physical Metallurgy	Imperfections in crystals-point defects, dislocations and voids, theory of dislocations, strengthening mechanisms, diffusion in solids, heat treatments and phase transformations, mechanical response and microstructure-property relationship
MS2030 **2** Materials Characterization II	X-ray diffraction and imaging, Properties of X-ray; Diffraction: Directions and intensities; Experimental methods: Laue diffraction, Powder diffraction, Diffractometer measurements; Applications: Crystal structure and size (grain and particle); Orientation; Phase diagram; Order-disorder transformations; Chemical analysis; Stress measurement, X-ray tomography. Electron diffraction and imaging: Reciprocal space; Electron diffraction pattern; Kikuchi diffraction; Convergent beam electron diffraction (CBED) pattern; Imaging: Amplitude contrast, phase-contrast, thickness-bend contrast; Secondary electron imaging; Back scatter electron imaging
MS2040 **2** Advanced Materials Synthesis	Basics of nucleation and growth processes in solution based synthesis. Solid liquid interface interactions Influence of reaction conditions on morphological properties of materials. Approaches for synthesis of nanomaterial. Basics of sintering process- chemical reaction and phase transformation kinetics in solids. Solid substrate- vapour interactions in CVD, PVD. Effect of vapour deposition conditions on growth and morphology of ceramic films
MS2050 **2** Mechanical Behaviour of Materials	Hardness testing, Tensile and compression testing, Torsion testing, Fatigue testing, Fracture, High temperature deformation- Creep and superplasticity, Impact testing and failure
MS2060 **2** Functional and Structural Polymers	Structural polymers, crystallisation in polymers (types and mechanism), mechanical behaviour - viscoelasticity -spring dash pod models - relaxation behaviour (time and temperature effect), functional polymers (conducting polymers, liquid crystalline polymers, polymeric photonic crystals), characterisation- scattering by polymers, flow in polymers- rheology, polymer blends and composites, blending (solubility and compatibility),
MS2070 **1**	Introduction, Ceramic Materials: structure, microstructure and polymorphism, synthesis

Ceramics and Refractories		of ceramics, ceramic forming processes, structural ceramics, Properties and applications. Refractory materials, Properties of Refractories, Fracture of refractories, Corrosion of Refractories, Different Refractory lines, Testing of Refractory Materials.
MS2080 Process Metallurgy	**1**	Introduction to primary metallurgical processes; chemical stoichiometry; thermochemistry; material and energy balance during processes; thermodynamics of processes: standard free energy change and Ellingham diagram, Raoult's and Henry's laws, concept of different standard states and their inter-conversion
MS2090 Electronic Materials	**1**	Dielectrics - Polarizability, Temperature and frequency effects - Dielectric breakdown - high-k dielectrics - DRAM devices - Ferroelectrics - structural phase transitions - Domains - Domain walls - Domain Switching - Piezo-pyro and anti-ferroelectrics - Multiferroics - Relaxor materials - NVRAM applications - low dimensional insulators - Introduction to interaction of light with electrons in solids; absorption, colour, refraction, polarization, optical process
MS2100 Rate Phenomena in Process Metallurgy	**1**	Mass and energy balance in metallurgical processes; Applications of heat and mass transfer in steel making; concepts of physical and mathematical modeling of metallurgical processes (iron making, steel making, etc.)
MS3010 Magnetic Materials	**1**	Origin of magnetism - Types of magnetic materials: dia-para-ferro-ferri and antiferro-magnetism - Soft and Hard magnetic materials - Domains and Domain walls - Experimental observation of Domains - CMR - magneto caloric materials - spin glasses - magneto optic materials - MOKE
MS3020 Casting and Solidification	**2**	Overview of casting and solidification processing; steps in producing a cast product; relative advantages and shortcomings of casting as a processing technique; expendable and permanent mold casting; gating and riser design; difference in solidification of pure metals and alloys; melt quality; casting defects; heat transfer fundamentals related to casting and solidification; solution of Stefan problem for idealized conditions; three cases of directional solidification of binary alloys: equilibrium, Scheil (macrosegration) and steady state; constitutional supercooling; formation of cells, dendrites and equiaxed zone; processing-microstructure (G-V) maps.
MS3030 Non-ferrous Extractive Metallurgy	**1**	Basics of extractive metallurgy (thermodynamic, kinetic and electrochemical aspects). Types of extractive metallurgy processes ((Pyro-metallurgy, Hydrometallurgy and electrometallurgy), extraction from oxides, halides and sulphide ores. Refining and purification. Waste management, energy and environmental issues in nonferrous metals extraction
MS3040 Thin Films	**2**	Introduction to thin films: Definition of thin films - Formation of thin films, Environment for thin film deposition; Deposition parameters and their effects on film growth, Substrates - overview of various substrates utilized. Vacuum technology, Physical vapor deposition (PVD) techniques, Chemical vapor deposition techniques, Metallorganic (MO) CVD, Epitaxy Thickness Determination techniques, Characterization of Thin film.
MS3050 Iron Making	**1**	Raw Materials for Iron Making, Burden Preparation from raw materials, Blast Furnace design and operations, Physical-Thermal-Chemical Processes in a Blast Furnace, Alternative Routes of Iron Production
MS3060 Steel Making	**1**	Acidic and basic steelmaking processes, principles of C, Si, Mn, S and P removal, selected steel making processes, ingot casting, continuous casting of steels
MS3070 Powder Metallurgy	**2**	Historical perspective, scope of powder metallurgy industries, techniques of near net shape manufacturing, techniques of powder manufacturing, characterization of powders, powder compaction methods, introduction to sintering, post-sintering operations.
MS3080 Computational Methods in Materials Science II	**2**	Conservation and continuity equations; Constitutive equations describing behaviour of materials; Numerical solution of ordinary and partial differential equations - finite difference and finite volume methods, spectral methods; numerical implementation of random walk model; overview of mesoscale modelling - phase-field models, cellular automata, dislocation dynamics; overview of atomistic simulations - molecular dynamics, Monte Carlo methods; application of quantum mechanics - electronic structure calculations.
MS3090 Phase Equilibria	**1**	Concepts of classical thermodynamics - first, second and third laws - extensive and intensive properties; Heat capacity, enthalpy, entropy and Gibbs free energy; Partial molar quantities - chemical potential; Phase equilibrium in single component systems; Ideal and nonideal solutions; Gibbs free energy composition diagrams; Phase diagrams

MS3100 **2**
Kinetics of Materials

Principles of diffusion in continuum - continuity equation; Concepts of fields, fluxes and gradients; Fick's laws of diffusion - steady state and nonsteady state; Solutions to the diffusion equation; Atomic mechanisms of diffusion - random walk; Interstitial and substitutional diffusion; Solutions to diffusion equations; Interdiffusion - Kirkendall effect, Darken relations.

MS3110 **2**
Transport Phenomena

Concepts of fluid flow, heat and mass transfer; Viscosity; Flow through porous media; Heat transfer - conduction, convection and radiation; Diffusion and advection; Analogy between heat and mass transfer; Unit operations in process metallurgy.

MS3120 **2**
Phase Transformations

Overview of phase transformations - thermodynamic driving force; Theory of nucleation - homogeneous and heterogeneous nucleation; Diffusional growth and interface controlled growth; Precipitation; Phase separation - spinodal microstructures; Particle coarsening; Eutectoid, massive, disorder-to-order, martensitic transformations; Elastic stress effects on microstructural evolution;

MS3130 **1**
Non Destructive Testing

Types of discontinuities in different product forms, principles of NDT Methods and techniques, applications, ultrasonic testing, radiographic testing and other techniques, limitations.

MS3140 **1**
Technical Communication

Drafting of communication- written content - organization of content elements, writing style, formatting and grammar. Data and image representation. Reference management. Ethical issues in technical communication.

MS3150 **1**
Corrosion

Thermal and electrochemical basis for corrosion in metallic materials. Types of corrosion (general, Galvanic, Intergranular, Crevice, Pitting, Erosion etc.) detection and analysis of corrosion. Preventive measures and economical consideration

MS3160 **1**
Aerospace Materials

Aerospace materials - Past, present and future; Materials and materials requirements for aerospace structure and engine; Production, casting, processing and machining of aerospace materials; Mechanical and durability testing of aerospace materials; Degradation and protection for aerospace materials Science and engineering of aerospace materials - Aluminium alloys, Titanium alloys, Magnesium alloys, Steels, Superalloys, Polymers, Composites

MS3170 **1**
Additive Manufacturing Technology

Overview, Direct digital manufacturing, types of additive manufacturing processes, additive manufacturing of different materials, selective laser sintering, Direct Metal Deposition (DMD) and Laser Engineered Net Shaping (LENS), structure and properties.

MS3190 **1**
Low Dimensional Materials

Classification of low dimensional materials (Zero-, one-, two-, and three dimensional nanostructures-quantum dots, quantum wells, quantum rods, quantum wires.)- Synthetic approaches for nanomaterial fabrication. Effect of confinement on materials properties (optical, electronic, magnetic, mechanical etc.). Applications of nanomaterial.

MS3210 **1**
Carbon Materials

Classification physicochemical properties and applications of conventional carbon based materials (activated carbon, graphite, diamond). Nanocarbons (carbon nanofibers, nanotubes, fullerenes, graphene) effect of size and shape on their physical and functional properties.

MS3220 **1**
Amorphous Materials

Amorphous semiconductors - Band tailing - Fermi pinning - phase change materials - switching behavior - optical and mobility gap - magnetic metallic glasses, Glasses, Bulk Metallic Glasses, Amorphous alloys,

MS3240 **2**
Metal Joining

Classes of metal joining techniques; different welding processes: constant current vs constant voltage, low vs high energy density; weld defects; heat transfer fundamentals in welding: Rosenthal model and weld thermal cycle; process parameter-weld pool geometry correlation; solidifcation fundamentals applied to weld solidification and microstructure development: thermal gradient, speed of solidification and cooling rate.

MS3250 **2**
Surface Engineering

Surface dependent engineering properties, common surface initiated engineering failures, mechanism of surface degradation, classification and scope of surface engineering in metals, ceramics, polymers and composites, Surface protection and surface modification techniques.

MS3260 **2**
Biomaterials

Application of materials in medicine: introduction to structure and biological properties of hard and soft tissues and requirement of implant materials. Classification of implant materials (metallic, ceramic, polymeric), physical, mechanical and biological attributes necessary for specific implant function. Practical aspects of Implant materials- host tissue response, implant failure.

MS4010 **1**

Types of Defects - Colour centres - optical emission - solid state lasers - Luminescence -

Defects in Functional Materials		types of luminescence - Band gap tuning - ionic conductivity - Varistors - Gas sensors - Characterization techniques of Defects - Demerits of defects - Defect induced functional failures
MS4020	**1**	Defining research problem, laboratory safety measures, do's and don'ts of data collection and processing (graphical, statistical, image processing etc.). Ethical issues with laboratory protocol and data reporting.
Research Methodology		
MS4030	**1**	The design process - Function, material, shape and process relationship with data. The selection process - Material and shape co-selection from charts, process selection with diagrams. Various case studies.
Materials Selection and Design		
MS4040	**1**	Introduction, Environmental issues, Waste characterization, Size reduction and classification, techniques of materials separations, methods of recycling of papers, glass, plastics and metals, Recycling of precious materials.
Recycling of Materials		
MS4050	**2**	Mechanisms of fatigue in metals - stages of fatigue, constitutive relations; Design for fatigue - microstructural aspects; Fracture mechanisms in brittle and ductile solids; Thermodynamics of fracture - Griffith theory; Measurement of toughness.
Fatigue and Fracture		
MS4060	**2**	Work-hardening mechanisms, static and dynamic softening processes, processing techniques, thermo-mechanical processing of steel, aluminium, magnesium, titanium and advanced alloy systems
Thermo-mechanical Processing		
MS4070	**1**	Different paradigms of fabrication: Top-down and bottom-up approach; Top-down techniques; E-beam lithography; Photo lithography; Focused ion beam (FIB) lithography; Direct laser writing and laser interference lithography; Bottom-up techniques: Self-assembly from nanoparticles; DNA assisted self-assembly; Assembly using linker molecules
Introduction to Nanofabrication		
MS4080	**1**	Description of orientation, representation of texture, measurement of texture, Texture of FCC, BCC and HCP materials
Crystallographic Texture		
MS4090	**1**	Introduction to trobological systems and their characteristic features; analysis and assessment of surface; techniques of surface examination, friction and measurement, mechanism of wear, types of wear, quantitative laws of wear, measurement of wear, wears resistance materials.
Wear and Tribology		
MS4100	**1**	Study of natural materials existing in different environmental conditions such as wood, bone and glass sponge - understanding of their structure, property and synthesis, Supramolecular organisation in natural fibres (cellulose, silk, collagen) and biological macromolecules (DNA)- molecular interactions (driving force for supramolecular assembly), structural properties. Implementation in material synthesis for applications
Supramolecular Materials		
MS4110	**1**	Introduction to the interactions between cells and the surfaces of biomaterials. Surface chemistry and physics of selected metals, polymers, and ceramics; surface characterization methodology; modification of biomaterials surfaces; Introduction to materials in biosensors and microarrays, implants, drug delivery, and tissue engineering.
Antifouling and Health Care Materials		
MS4120	**1**	Phonons - specific heat capacity - Free electron model, Einstein and Debye theory - Phonon dispersion in solids - Thermal conductivity - Thermal expansion - Thermoelectric solids - electron phonon scattering - soft and hard phonons - solid state spectroscopic techniques
Phonons in Solids		
MS4130	**1**	What are Liquid crystals, types of liquid crystals, theories of formation, properties of liquid crystals, phase transitions - temp driven and concentration driven, characterisation of liquid crystals - DSC, POM, SAXS, common applications and processing
Liquid Crystals		
MS4140	**2**	Fundamental concepts of Electrochemistry, Electrical double layer and it's importance, concepts of electrode potential, over potential and it's practical implications, The Butler-Volmer equation, introduction to electrochemical analytical techniques like cyclic voltametry, electro chemical polarization and electrochemical impedance spectroscopy; Examples of applied electrochemistry: Batteries, Fuel Cells, the Lithium Ion Battery, applications in extractive metallurgy - electrowinning and other techniques like electrochemical deposition.
Applications of Electrochemistry in Materials Science and Engineering		
MS4150	**1**	Conventional vs high entropy alloy (HEA) design, thermodynamic aspects, structure and properties of single and multiphase HEAs, special subclasses of HEAs, high entropy related materials including oxides, carbides, nitrides and borides and their properties
High Entropy Materials		

MS4160 **2**
Energy Materials

Green energy resources: Introduction to non- conventional energy resources- Overview of solar cells, battery and fuel cell technology. Materials properties, challenges and current developments in each category

MS4170 **2**
Introduction to Functional Ceramics

Special structures: Zinc blende, Rock salt, fluorites, perovskites, double perovskites, layered perovskites, pyrochlores and polymorphs, Transition metal oxides: Gas sensors, varistors, wide bandgap oxides, solid state electrolytes, ionic conductors. Piezoelectric ceramics: lead based and lead free piezoelectrics, piezoelectric coefficients, measurements and devices, ferroelectricity, and multiferroics.

MS4180 **2**
Semiconductors and Devices

Junction formation - Electronic transport in junctions - Excitons - pn diode - Band structure under biased conditions - solar cells - diode lasers - LED - Photodiodes - Quantum heterostructures - Quantum tunnelling - Tunnel diodes - Resonant Tunnel Diodes - Coloumb blockade conduction - Quantum cascade lasers - MOS capacitors - Silicon and its applications - Conversion of indirect to direct band gap semiconductors - Quantum dots - opto-electronic devices

MS4190 **2**
Recent Developments in 2d Materials Science

This course is aimed at introducing the various techniques and principles associated with the synthesis and characterization of novel 2D materials. We will cover the latest advances development of these 2D materials and their potential application. For example, a group of materials expected to be studied include Graphene and other 2D materials (MoS2, TeS2, WSe2 etc.).

MS4200 **2**
Composites

Introduction, classification of composites, strengthening mechanism in composite, types of reinforcements, production methods for reinforcements, metal matrix composites, carbon-carbon composites, ceramic matrix composites, polymer matrix composites, interfaces and interphases, properties.

MS4210 **2**
Fundamentals of Plasmonics

Introduction to nano-optics and plasmonic, Restrictions on materials for plasmonics, Localized plasmons, Effect of shape, size and material, Multiple particle assemblies - Analogy to molecular hybridization, Biosensing and molecular recognition (SERS/SEIRA), Molecular modification of nanoparticle surfaces, Nanofabrication using localized plasmons, Characterization techniques - Far-field techniques (BF/DF microscopy, Fourier plane imaging), near-field techniques (near-field scanning optical microsope)

MS5140 **3**
Introduction to Computational Methods in Materials Science

Basic concepts of modeling and simulation in materials science and engineering - why do we need to model across length scales; concepts of transport phenomena - conservation and continuity equations; constitutive equations describing behavior of materials; introduction to ordinary and partial differential equations - initial and boundary conditions; numerical methods - finite difference method, finite element method, spectral method for periodic boundary conditions; description of materials properties and phenomena using vector and tensor representations; introduction to mesoscale methods - phase-field model, continuum crystal plasticity; introduction to atomistic simulations - molecular dynamics, Monte Carlo methods; application of quantum physics - electronic structure calculations.
The course uses open source computational tools and MATLAB programs to demonstrate the fundamentals and applications of the computational methods to key technological problems.

MS5150 **2**
Biomaterials- Materials in Medicine

Application of materials in medicine: introduction to structure and biological properties of cardiovascular, orthodontic, ophthalmic and soft tissues and requirement of implant materials Metallic Implants: physical, mechanical properties and corrosion behavior of metallic materials, surface modification, Implant design and processing, examples of bone, stents and surgical implants, Ceramic and composite implants materials: chemical and structural and biological properties of ceramic materials, synthetic methods for ceramic and composite materials, Biomimetic approach towards composite design and bioresorbable implants, examples of ceramic and composite materials in orthodontic implants, Polymeric materials: Synthetic and biopolymers, chemical properties, thermomechanical behavior, examples of polymeric materials in cardiovascular, ophthalmic and other soft tissue implant applications, Practical aspects of Implant materials: host tissue response, implant failure

MS5160 **3**
Polymer Science and Engineering

The objective is to teach basics in polymer physics, relate it to polymer structure, processing and applications. This course also aims to introduce conventional characterisations techniques in context of polymers.
Introduction to polymers- synthetic and natural (wood, silk) , structure (states and configuration) of polymers- spring dash pod models - relaxation behaviour, structure - properties relationship and application, processing techniques and product development (eg fibre spinning), introduction to functional polymers (eg liquid crystalline polymers),

		characterisation- XRD, SAXS, SEM, TGA, DSC, flow in polymers- rheology, composites (natural and synthetic), networks and hydrogels
MS5170 Thermodynamics and Kinetics of Materials	**0**	Concepts of classical and statistical thermodynamics - extensive and intensive properties - heat capacity, enthalpy, entropy and Gibbs free energy; Partial molar quantities - chemical potential, Gibbs-Duhem relations; Phase equilibrium in single component systems; Ideal and nonideal behavior of solutions; Gibbs free energy composition diagrams; Phase diagrams; Multicomponent phase equilibria; Irreversible thermodynamics - diffusion in continuum - continuity equation; Concepts of fields, fluxes and gradients; Fick's laws of diffusion - steady state and nonsteady state; Solutions to the diffusion equation; Atomic mechanisms of diffusion - random walk; Interstitial and substitutional diffusion; Solutions to diffusion equations; Interdiffusion - Kirkendall effect, Darken relations; Diffusion in multicomponent systems.
MS5190 Soft Materials	**3**	Introduction to 'soft' materials in terms of structure, property- Colloids, foams, gels, liquid crystals, soft biological materials such as DNA, and polymers (synthetic and natural) Structure (states and configuration) of polymers, synthesis, effect of temperature (glass transition and melting), branching, cross-linking on properties, crystallisation in polymers (types and mechanism), mechanical behaviour - viscoelasticity -spring dash pod models - relaxation behaviour (time and temperature effect) Self-assembly and Supramolecular organisation with reference to cellulose, silk, collagen and biological macromolecules
MS5200 Phase Transformations	**3**	Phase transformations and microstructure formation; different classifications: first order vs higher order, diffusional vs diffusionless, discontinuous vs continuous; free energy-composition diagrams; nature of interfaces in crystalline materials and their role in phase transformations; thermodynamics and kinetics of nucleation; solid state precipitation: phase diagram, stable and metastable/intermediate phases, solvus temperatures, growth forms and kinetics, discontinuous precipitation; spinodal decomposition and disorder-order transformations; eutectoid transformation; massive transformation; martensitic transformation and shape memory effect.
MS5210 Hierarchical Nanostructured Materials	**1**	Natural hierarchical materials - bone, nacre, butterfly wing and so on, Advantages of hierarchical nanostructural organisation - mechanical, colours, and other functional benefits
MS5220 Nature Inspired Materials Engineering	**2**	Nature inspired material engineering and design for applications such as environment, energy and healthcare applications, bottom up assembly techniques and production, gap between natural and nature inspired materials
MS5230 Nature Inspired Materials Engineering for Mechanical Application	**1**	Design and Fabrication methods for producing nature inspired materials with enhanced mechanical properties, including optimisation of toughness and strength like in nacre or bone, introduction to materials and their synthesis for actuation properties like muscle, selection and design of materials for regenerative medicine
MS5240 Nature Inspired Materials Engineering for Wettability, Optical Tunability	**1**	Introduction of top down and bottom up fabrication techniques; Usage of combination of approaches to achieve tunability in wettability (similar to hydrophobicity of lotus) and optical properties such as reflection, colours (similar to peacock or moth's eye) and interaction (adhesive properties of gecko's foot)

14.15 Department of Physics

EP1017 Classical Physics	**1**	Brief introduction to Newtonian mechanics, Constraints, Generalized coordinates, Degree of freedom, Virtual work, D'Alembert's Principle of virtual work, Lagrangian formalism, Hamilton's equation, Central force problem (equation of orbits, motion of planets and satellites), Rigid body dynamics
EP1027 Maxwell's Equations and Electromagnetic Waves	**1**	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
EP1567	**1**	Vector Algebra, Matrices and determinants, Vector calculus (gradient, divergence, curl

Mathematical Methods for Physicists -I	and related theorems), Line, surface and volume integrals, Curvilinear coordinates (spherical and cylindrical polar, Jacobian, grad, divergence, curl, Laplacian)
EP1577 2 Mathematical Methods for Physicists -II	Infinite sequences and series - convergence and divergence, conditional and absolute convergence, ratio test for convergence, Special functions (Euler beta and gamma, Heaviside Step function, Dirac Delta function, Kronecker delta), Probability and Statistics (Various distributions e.g. Gaussian, Poisson, Binomial, Error analysis), Fourier Series and transforms, Laplace series and transforms, Ordinary differential equations, Partial differential equations: First order, second order, separation of variables, Laplace and Poisson equations, Wave equations.
EP1587 1 Tensors and Differential Forms	Tensor Analysis, Pseudo and Dual tensors, Tensors in general coordinates, Jacobians, Differential forms: Differentiating and integrating forms
EP2017 1 Relativity	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.
EP2027 1 Quantum Physics	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 orthonormalization of basis vectors, basis sets, change of basis, eigenstate and eigenvalues, expectation values.
EP2127 1 Astroparticle Physics	Natural system of units, elementary particles of nature, Fundamental forces of nature, Concepts of metric, Robertson-Walker metric, Particle kinematics in FRW Universe, Particle dynamics of FRW universe, redshift, thermodynamics in the early universe, time, temperature and entropy, Boltzmann distribution and decoupling temperature of massive particles, neutrino decoupling, matter-radiation equality, photon-decoupling and recombination, baryon number of the Universe, horizons.
EP2177 1 Linear Vector Spaces	Linear vector space, Metric space, Function space, Hilbert space, Linear operators, N-dim. vector space, Tensors, Transformation of basis, Invariant subspaces, Hermitian and Unitary matrices.
EP2187 1 Fourier Series and Integral Transforms	Fourier series, Fourier transforms, Convolution theorem, Laplace transforms, Applications of Fourier and laplace transforms
EP2197 1 Complex Analysis	Analytic functions, Cauchy theorem, Cauchy's integral representations, Taylor and Laurent series, Calculus of residues, Analytic continuation, conformal mapping.
EP2217 1 Classical Electromagnetism	Coulomb's law, Electric field, Divergence and curl of electrostatic fields, electric potential, work and energy in electrostatics, conductors, Special techniques to solve Laplace's equations, Method of images, separation of variables and Multiple expansion, Polarization, Field of a polarized object, Electric displacement and linear dielectrics. Lorentz force law, Biot-Savart Law, Divergence and curl of B, magnetic vector potential, magnetization, field of a magnetized object, linear and nonlinear media
EP2218 2 Electrodynamics	Electromotive force, Electromagnetic induction, Maxwell's equations, conservation laws, Poynting theorem, Maxwell's stress tensor, conservation of momentum, angular momentum, and electromagnetic waves, Electromagnetic waves in vacuum, Electromagnetic waves in matter, Absorption and Dispersion, Wave Guides, Potentials and fields, Gauge transformations, Coulomb Gauge and Lorentz Gauge, Dipole radiation, Power radiated by point charge.
EP2287 1 Special Functions and Differential Equations	Series solution, separation of variables, Sturm-Liouville theory, Bessel equation and function, Legendre equation and function, Spherical harmonics, Green function and Nonhomogeneous differential equations, Special functions such as hermite, Laguerre, Chebyshev etc.
EP2297 1 Group Theory	Class, Cosets, Factor group, Character table, Reducible and Irreducible representations, Lie groups, Applications of group theory in Physics

EP2817 **1**
Modern Physics

Photo Electric Effect, Compton Effect, Atomic Spectra and Lasers, Bohr and deBroglie models, Stern-Gerlach and Entanglement experiments, Matter waves and Schrodinger Equation, Tunnelling, decay, STMs, Hydrogen Atom and Molecular Bonding, Conductivity, Semiconductors, BEC.
Pre-Req: Courses on Relativity and Quantum Physics

EP2827 **1**
Thermodynamics

Kinetic theory of Gases, Maxwell-Boltzmann Distribution, molecular distribution, mean free path and collisions, transport and thermal diffusion, viscosity, thermal conductivity. Thermodynamic systems, First law of Thermodynamics, Second law of Thermodynamics, Clausius theorem, thermodynamics and statistical definition of Entropy, Gibbs paradox, Entropy and probability, internal energy and heat capacity equations and their applications.
Pre-req: Courses on Classical Physics and Electromagnetism and Maxwells Eqn.

EP2897 **1**
Accelerator Physics -I

Particle Accelerators, EandM in Particle Accelerators, Linear Beam Optics in straight systems, Linear Beam Optics in Circular Accelerators. RF systems for Particle Accelerators

EP3027 **1**
Accelerator Physics

Charged Particle Motion in Static Fields, Linear Transverse Motion, acceleration and longitudinal motion; Examples of Cyclotron, Linear Collider and Synchrotron, applications of accelerator physics.

EP3028 **2**
Accelerator Physics-ii
▷EP2218

Accelerator magnets, Particle Dynamics, Steady state Electric and Magnetic fields, Modifications of Eand B fields by Materials, Electric and Magnetic field Lenses, Focusing Fields, LINAC, Betatrons, Phase Dynamics; effects of linear magnet errors; chromatic effects and their correction; effects of nonlinearities; basic beam manipulations; RF systems, diagnostic systems; and introduction to accelerator lattice design. Other topics such as synchrotron radiation excitation and damping; beam-beam interaction; collective effects and instabilities; linear accelerators

EP3100 **2**
Advanced Special Relativity
▷EP2017

- Lorentz transformations, Relativistic four-vector notation
- Lorentz Group and Poincare Group: Lorentz tensors
- Infinitesimal transformations: Generators and Lie-derivatives
- Conservation laws for Lorentz symmetry: Noether charges,
- Lorentz Covariant laws of physics: Point Particle, Fluid mechanics, Electrodynamics and Lorentz force law, Relativistic Thermodynamics and Optics (Optional).

EP3117 **1**
Wave Formalism of Quantum Mechanics
▷EP2027

Schrodinger Equation in one dimension, probability current density, equation of continuity, Free particle solution of Schrodinger equation, box and delta function normalisation of free particle solution, potential step, potential barrier, particle in a infinite potential box, square well potential and tunnelling, linear harmonic oscillator.

EP3127 **1**
Hydrogenic Atom
▷EP2027

Orbital and spin angular momentum operators, angular momentum algebra, eigenstates and eigenvalues of angular momentum, addition of angular momenta, Clebsch-Gordon coefficients, spin-orbit interaction and applications, central potential, solutions of schrodinger equation in a central potential, Hydrogen-like atom, 3 dimensional harmonic oscillator.

EP3128 **2**
Group Theory for Physicists

Continuous groups/ algebras: SU(2), SU(3), SO(N), SU(N), representations and applications in modern physics. Lorentz Group and applications, Discrete groups: S3, S4, A4... etc. and applications.

EP3138 **2**
Plasma Physics and Applications

Introduction, Motion of charged particles in fields, Waves in plasmas, Methods of plasma production, Ionization and equilibrium models in a plasma, Radiation from plasmas and diagnostics, Absorption processes and instabilities in plasmas, Laser Plasma Interaction.

EP3150 **1**
Magnetohydrodynamics
▷EP2218

Modes of description of a plasma . Collisional plasma. The one-fluid description .The two-fluid description. Collisionless plasma. The guiding center limit of the Vlasov equation. The double adiabatic theory .Consequences of the MHD description . Conservation relations. Flux frozen in plasma

EP3188 **2**
Physics of Solar Cell

Basic principles of Photovoltaics; characteristics of the photovoltaic cell; Semiconductor physics: generation and recombination of electrons and holes,
junctions; analysis of
junctions; Silicon solar cells; thin film solar cells; third generation solar cells; managing light; Thermodynamic limit to efficiency-The Shockley-Queisser limit; Advanced strategies for high efficiency solar cells;

EP3198 **2**
Organic Electronics

Organic semiconductor device physics; Semiconducting polymer Physics; Organic Transistors; Advanced materials for organic electronics; Organic Photovoltaics; Organic light emitting diodes; Fabrications techniques for organic electronics.

EP3218 **2**
Classical Theory of Fields
Special theory of relativity and relativistic kinematics, Covariant (Lagrangian) formulation of electrodynamics, interaction between particles and fields: dynamics of charges and electromagnetic field.

EP3227 **1**
Nonlinear Dynamics
▷EP2027
Nonliner methods and chaos, stability, logistic map, Nonlinear differential equations

EP3237 **1**
Approximation Methods in Quantum Mechanics
Time independent perturbation theory for non-degenerate and degenerate energy levels, variational method, WKB approximation and applications, time dependent perturbation theory, Fermi-golden rule, adiabatic approximation, sudden approximation.

EP3238 **2**
Laser Technology
▷EP3338
Atomic Radiation - line shape and broadening of spectral lines; Laser oscillations and amplification - gain saturation in homogenous and inhomogenous broadened transitions; General characteristics of Lasers; Methods of generating short and ultrashort pulses – Q switching and Mode locking; Laser systems; Frequency multiplication of laser beam - introduction to nonlinear optical phenomena, second harmonic generation, optical parametric oscillation and implication.

EP3257 **1**
Numerical Methods
▷EP3117
Linear Systems: Gauss elimination, LU-Factorization, Eigenvalues by iterations
Numerical differentiation and integration
Interpolation, Splines, Solution of equations by iterations
Numerical methods for differential equations

EP3267 **1**
Symmetries in Quantum Mechanics
▷EP3117
Schrodinger and Heisenberg pictures, interaction picture, unitary transformations, symmetry principle and conservation laws, translation along spatial and temporal directions, spatial rotation and conservation of angular momentum, space reflection and parity conservation, time reversal invariance.

EP3268 **2**
Computational Solid State Physics
Electronic structure methods; density functional framework; Tight binding theory; computations of band structure and electronic states; electronic structure of semiconductor, magnetic and dielectric materials.

EP3277 **1**
Relativistic Quantum Mechanics
▷EP3237
Elements of relativistic quantum mechanics, the Klein-Gordon equation, the Dirac equation, Dirac matrices, spinors, positive and negative energy solutions, physical interpretations, non-relativistic limit of Klein-Gordon and Dirac equations, equation of continuity and probability current density.

EP3278 **2**
Physics of Surfaces and Interfaces
Electronic surface states, Surface phonons, Scattering from surfaces and thin films, Statistical thermodynamics of surfaces, Metal-semiconductor junctions, semiconductor heterostructures, Oxide surfaces, Collective phenomena at interfaces

EP3287 **1**
Atomic-molecular Physics
The Schroedinger equation for One-electron Atoms, Special Hydrogenic systems, Interaction of one electron atoms with Electromagnetic Radiation, One-electron atoms: Fine Structure and Hyperfine Structure

EP3288 **2**
Analytical Mechanics
Hamilton's principle, Galilean invariance, Lagrangian and Lagrangian density, symmetry and conservation laws, scattering, small oscillations, rigid body dynamics, canonical equations, canonical transformations, action-angle variables, Hamilton-Jacobi.

EP3317 **1**
Thermal Physics
Laws of thermodynamics, entropy, Clausius theorem, approach to equilibrium, stability conditions; random variables, probability distributions, central limit theorem, information and uncertainty, entropy maximization under constraints.

EP3337 **1**
High Energy Physics
Basic constituents of matter, Forces in nature, Accelerators: Cosmic and Manmade, Detectors, Exotic Matter

EP3338 **2**
Photonics and Laser
▷EP2117, EP1027
Polarization, Interference and Coherence of Light, Linear Interaction between Light and Matter, Non-linear Interaction between Light and Matter without absorption, Non-linear Interaction between Light and Matter with absorption, Lasers

EP3347 **1**
Crystal Structure
Classification of solids- crystalline and non-crystalline solids - 2D and 3D lattice types - different crystal structures - Diffraction of waves by crystals: Bragg's law - Reciprocal lattice - Brillouin zones

EP3348 **2**
Statistical Physics
▷EP3317
Liouville's theorem, ensembles: microcanonical, canonical and grand canonical; mixing entropy and Gibb's paradox, equilibrium distributions, partition functions, fluctuations and response, equivalence of ensembles; Quantum statistical mechanics: density matrix, quantum ensembles, quantum ideal gas, Fermions and Bosons, occupation number,

		equation of state, ideal Fermi gas, Pauli paramagnetism, ideal Bose gas, black body radiation, Bose-Einstein condensation.
EP3358 Spectroscopy	**2**	Interaction of one-electron atoms with external electric and magnetic fields, Two electron atoms, Many electron atoms, Interaction of many-electron atoms with Electromagnetic Radiation and with static and magnetic fields, Molecular structure, Molecular Spectra, Electron-Atom Collisions and atomic photoionisation
EP3367 Experimental Techniques	**2**	Vacuum Techniques, Spectroscopic Techniques, Charged Particle Optics, Data Analysis, Error Analysis
EP3398 Computational Physics	**2**	Introduction to programming in C++/C/Fortran/MATLAB Numerical differentiation and integration Gauss elimination, LU-Factorization, Eigenvalues by iterations Numerical methods for differential equations
EP3417 Elasticity	**1**	Displacement vector, strain tensor, dilation and shear, stress tensor, translational and rotational equilibrium, elastic free energy, elastic moduli, linear response, isotropic solid, elastic wave propagation, seismic wave.
EP3478 Particle Physics ▷EP2127	**2**	Classification of particles, Quark contents of Hadrons, Particle quantum numbers, Gell-Mann Nishijima formula, Relativistic kinematics, scattering amplitudes, Cross sections, decay rate and life-time. Breight-Wigner formula, Continuous symmetries and conservation laws. Discrete symmetries. CPT theorem, Weak processes, pion decay, GIM mechanism, Parity violation, CP violation, Quark mixing, CKM matrix, Neutrino Physics, Elements of Quantum Chromodynamics, Electroweak interaction, Symmetry breaking and Higgs mechanism, Standard Model of Particle Physics and Physics beyond the standard model.
EP3518 Physical Biology of the Cell	**2**	The cell and subcellular components, cell division, motility, force generation, signalling; Physical principles: noise, diffusion, random walk in biology, Langevin and Fokker-Planck, first passage problems, polymers and membranes; F-actins, microtubules, cell membranes, motor proteins, chromosome, DNA to protein: translation and transcription.
EP3527 Fluid Mechanics ▷for honors students	**1**	Conserved quantities and continuity, Euler's equation, hydrostatics, streamline flow, vortices, Bernoulli's equation, energy and momentum flux, incompressible fluids, flow past bodies, viscous fluids - Navier Stokes equation, energy dissipation, Stoke's formula.
EP3528 Non-equilibrium Statistical Mechanics	**2**	Brownian motion, Langevin and Fokker-Planck equations, Zwanzig formalism, Master equations, Kramers problem, first passage time, energy diffusion, kinetic models, H-theorem, hydrodynamics, static and dynamics response.
EP3537 Nuclear Physics	**1**	Alpha decay: Tunnelling effect and probability, Geiger-Nuttall law, Electron and positron spectra, Neutrino mass, Kurie plot, Fermi theory of beta decay, Gamma decays, Nuclear models, Nuclear reactions, Direct reactions, Compound nucleus reactions.
EP3588 Computational Physics - I	**1**	Interpolation; Least square and spline approximation; numerical differentiation and integration; Numerical methods for matrices; Extremes of a function; Non-linear equations and roots of polynomials; Applications of numerical methods in Physics
EP3589 Computational Physics - II	**2**	Numerical methods for ordinary differential equations; Numerical solution of Sturn-Liouville and Schrodinger equation; Discrete and fast Fourier transforms; Molecular dynamics and Monte Carlo simulations; Numerical methods for partial differential equations; Applications of numerical methods in Physics
EP3592 Plasma Physics and Magnetohydrodynamics (mhd)	**2**	Plasma and its occurrence in nature, Concept of Temperature, Debye Shielding, Plasma Parameter, Criteria for Plasmas, Applications of Plasma Physics, Motion of charged particles in fields, Waves in plasmas Methods of plasma production, Ionization and equilibrium models in a plasma, Radiation from plasmas and diagnostics, Absorption processes and instabilities in plasmas, Laser Plasma Interaction Modes of description of a plasma, Collisional plasma, The one-fluid description, The two-fluid description. Collisionless plasma, The guiding center limit of the Vlasov equation, The double adiabatic theory, Consequences of the MHD description. Conservation relations, Flux frozen in plasma
EP3593 Optical Engineering	**1**	Basics of Geometrical Optics and Diffraction Theory, Optical Components: Mirrors, Lens, Prisms, Thin lens theory, Aberrations, Basic Optical Instruments, Lens Design and evaluation, Introduction to Optical Instrument design.

EP3638 **2**
Fundamentals of Semiconductors Physics and Devices

Classification of materials, Basic Semiconductor: energy bands, donors and acceptors, carrier concentration, carrier transport, generation recombination processes, basic equations for device operation, P-N junctions: electrostatics, space charge, abrupt and linearly graded, current-voltage and capacitance-voltage characteristics, junction breakdown, Metal-Semiconductor contact: Ohmic and non-ohmic, Schottky effect, current-voltage characteristics, Bipolar Transistor: transistor action, current gain, static characteristics, frequency response, transient behaviour, junction breakdown, metal-insulator-semiconductor (MIS), Metal-Oxide-Semiconductor (MOS) diode, C-V characteristics of MOS, Charge couple devices (CCD). Field Effect Transistor, MISFET, MOSFET, CMOS.

EP3648 **2**
Microfabrication Techniques

Crystal Structures, Crystal Growth, wafer fabrication, Oxidation, Diffusion, Ion Implantation, Metallization, Lithography, Wet Etching, Dry Etching, Chemical Mechanical Lapping and Polishing (CMP), Wafer bonding, Evolution of MEMS, Fabrication methods of MEMS: Microsteriolithography, Lithographie, Galvanoformung, Abformung (LIGA), Micromachining, etc. Bulk micromachining, Deep reactive Ion Etching (DRIE), Wet chemical based micromachining, Surface Micromachining, Stiction problems in surface micromachining.

EP3758 **2**
Nonlinear Dynamics and Chaos

Introduction to nonlinear dynamics, application to physics and engineering, one dimensional system, bifurcations, phase plane, nonlinear oscillators, Lorentz equations, Chaos, strange attractors, fractals, iterated mappings, periodic doubling.

EP3887 **1**
Introduction to General Relativity
▷Undergraduate Mathematical Physics and Classical Physics

Newton's theory of Gravitation and Mechanics: Failures and inconsistencies, Special Relativity: Minkowski Geometry, Curved Space-time: Riemannian geometry, Einstein Field Equations: Gravitation as curvature of space-time, Linearized approximation: Gravitational waves, Non-linear solution: Schwarzschild case, Cosmology
Pre-Req: Courses on Mathematical Physics and Classical Physics

EP4058 **2**
Superconductivity

Introduction to superconductivity, electrodynamics of superconductors, type II superconductors, critical magnetic fields, pinning, the critical state model, superconducting materials, and microscopic theory of superconductivity. The London equations, Ginzburg-Landau theory, The Josephson effect, BCS theory and the energy gap, London's model, flux quantization, Josephson Junctions, superconducting quantum devices, equivalent circuits, high-speed superconducting electronics, and quantized circuits for quantum computing. Unconventional super-conductors and super-conducting technology.

EP4068 **2**
Spintronics

Overview of spin electronics; Classes of magnetic materials; Quantum Mechanics of spin; Spin-orbit interaction; Exchange interaction; Spin relaxation mechanisms; Spin-dependent transport; Spin transfer torques; Current-driven switching of magnetization and domain wall motion; Spin injection, Silicon based spin electronic devices, Spin photo electronic devices, Nanostructures for spin electronics, Spintronic Biosensors, Spin transistors, Quantum Computing with spins.

EP4108 **2**
Fractal Concepts in Physics

Scaling concepts, roughening, dynamic scaling, self-similarity and fractals, fractal dimensions, self-affinity, physical examples: surface growth, interfaces, polymers; Linear theory - Edward-Wilkinson equation, Kardar-Parisi-Zhang equation: scaling and exponents, re-scaling in momentum space, RG-flow equations for KPZ, phase transitions in KPZ, dynamic RG: introduction, perturbation expansion, renormalization procedure, calculation of integrals

EP4110 **1**
Black Holes I: Static Black Holes
▷EP6887 or EP6458 or EP4258

- Gravitational Collapse: TLV equation, Neutron stars, Chandrasekhar limit
- The Schwarzschild solution of vacuum Einstein Equations
- Geodesics and trajectories, Horizons, Black holes and white holes
- Kruskal coordinates, Carter-Penrose diagrams, Eternal black hole
- Charged Black holes: Reissner-Nordstrom (RN) solutionExtreme RN solution, multicenter solutions.

Pre-Req: Static black holes, PH6887 (Introduction to General Relativity) or a course at the same level

EP4118 **2**
Laser Spectroscopy

Lasers Overview; Spectroscopic instrumentation; Doppler-limited Absorption and Fluorescence spectroscopy; nonlinear optics and Spectroscopy; Laser spectroscopy of Molecular Beams; Time resolved laser spectroscopy; coherent spectroscopy; THz spectroscopy

EP4120 **2**
Introduction to Astrophysics

Introduction to astronomical and astrophysical nomenclature and concepts. Coordinate systems, celestial orbits, radiation, stars, stellar structure and evolution, galaxies and

▷Modern EPysics (or equivalent). Also Electromagnetism and quantum Mechanics	galaxy clusters, Cosmology
EP4130 2 Statistical Data Analysis ▷Basic Probability and Statistics	Measurement, analysis; Probability distributions; Parameter Estimation; Hypothesis testing; Model Comparison; Confidence Intervals; Bayesian Analysis; Markov Chain Monte Carlo techniques; Dimensionality Reduction; Time-series analysis
EP4148 2 Ultrafast Optics ▷EP3338	Laser basics; Pulsed Optics; Principle of Mode-locking-Active and Passive; Femtosecond laser pulses; Ultrafast-pulse measurement methods; dispersion and dispersion compensation; ultrafast nonlinear optics; manipulation of ultrashort pulses; application of ultrashort pulses: time resolved and THz spectroscopy, coherent control; attosecond pulses.
EP4158 2 Feynman Diagram Techniques in Condensed Matter Physics	Second quantization; Zero and Finite temperature Green functions; Feynman rules; Homogeneous electron gas; Strongly correlated systems, Linear response theory
EP4160 0 Techniques in Particle Physics ▷see syllabus	We will explore different techniques to calculate different physical observables, viz. cross-sections, decay widths, differential distributions for different systems in particle physics. It will involve different numerical packages. Particle physics at the era of LHC also require to learn some simulations in order to have predictions closer to the experimental observations. Our aim is to learn PYTHIA, SARAH, micrOmegas, CaclHep, AlpGen etc. At the end we should be able to address various beyond Standard Model phenomenology. The course also require to have 'hands on' sessions, where we solve some problems using different tools. Pre-Req: Fortran, C, C++, Mathematica, basic knowledge of Standard Model, QFT
EP4170 1 Introduction to Ads/cft Duality ▷EP 6140, EP 6458, Perturbative String theory	Review of superstring theory, D-branes I: via (super)gravity, D-branes II: via (super)Yang Mills theory, Decoupling limit: AdS/CFT duality, Field -Operator mapping: Extracting Correlation functions, Holographic Renormalization,Wilson loops, Entanglement Entropy Pre-Req: Quantum Field Theory (Yang Mills), General Relativity (Charged Black holes, Multicenter solutions), Basic perturbative string theory.
EP4178 2 Micromagnetics	Introduction to micromagnetic equilibrium, solutions of micromagnetic equations, finite difference micromagnetics, finite element micromagnetics, micromagnetics of domain pattern, micromagneitcs of dynamic magnetization process, application of micromagnetics in modern magnetism
EP4180 1 Black Holes Ii: Stationary Black Holes ▷EP 4110 or EP 6110	• Rotating black holes: Kerr solution • Ergosphere and Ring Singularity • Penrose Process, Superradiance • Uniqueness theorems • Energy and Angular momentum (ADM, Komar) • Laws of black hole mechanics. Pre-Req: Static black holes, PH6887 (Introduction to General Relativity) or a course at the same level
EP4188 2 Theory of Phase Transitions	Mean field theory, symmetry and order parameter, Ginzburg-Landau theory, Ferromagnet-paramagnet transition, liquid-gas transition: critical point, coexistence curve, multicritical points, nematic-isotropic transition, liquid-solid transition - classical density functional theory, variational mean field theory; breakdown of mean field theory and construction of field theory, self-consistent field approximation, critical exponents, universality and scaling, ideas of renormalization group.
EP4217 1 Advances in Atomic and Molecular Imaging	Charged Particle Imaging in Chemical Dynamics; Velocity Map Imaging: Experimental Aspects; Reconstruction Methods (Abel and Hankel Inversion); 3-D Imaging
EP4248 2 Advanced Solid State Physics	Introduction of Many body techniques; Electron gas; Quantum theory of magnetism, Plasmons, Polaritons, Polarons, Excitons; optical processes in solids, Semi-classical and quantum transport in solids, BCS theory of superconductivity
EP4258 2 Gravitation and Cosmology	Review of Special Relativity, General relativity, Equivalence principle, tensor Analysis, Curvature of Space-time, Einstein's equation, The Schwarzschild solution, action

principle, Black Holes, Gravitational radiation, Isometries, Symmetric spaces, Cosmology.

EP4268 **2**
Advanced Particle Physics

Symmetries and Conservations laws, Noether's theorem, QED processes, Self energy corrections, Renormalization, QCD, Parton model, Electroweak theory, Spontaneous symmetry breaking, Grand Unified Theories,, Symmetries and Conservations laws, Noether's theorem, QED processes, Self energy corrections, Renormalization, QCD, Parton model, Electroweak theory, Spontaneous symmetry breaking, Grand Unified Theories,, Beyond the Standard Model, Gravitation and Cosmology.Beyond the Standard Model, Gravitation and Cosmology.

EP4298 **2**
Statistical Physics of Fields

Collective behaviour from particles to fields, continuous symmetry breaking and Goldstone modes, fluctuations and scattering, correlation functions and susceptibilities, lower critical dimension, Gaussian integrals - fluctuation corrections to saddle point, Ginzburg criterion, scaling hypothesis:
homogeneity assumption, divergence of correlation length, critical self-similarity, Gaussian model, the renormalization group (RG), perturbative RG: 1st order and 2nd order, the epsilon-expansion,
irrelevant variables; XY model, topological defects, Kosterlitz-Thouless type transitions, phase diagram from RG flow.

EP4378 **2**
Quantum Computation and Quantum Information

Classical logic gate operations, Single and multiple qubit quantum gates, Bell states and entanglement, Schmidt decomposition, EPR and Bell inequality, Idea of quantum teleportation, Deutsch algorithm, Shor's factoring algorithm, Principles of quantum search algorithm, Grover's algorithm, NMR and Computing, Classical Information theory, Shannon's coding theorem, Von Neumann entropy, Entropy of entanglement, Quantum noise, Elements quantum tomography and quantum cryptography

EP4388 **2**
Particle Astrophysics

Special Theory of Relativity, General Relativity, Elementary Standard model of particle physics, Standard model of Cosmology, Particle kinematics in FRW metric, Friedmann Equation, Dynamics of FRW Universe, Red-shift, Thermodynamics in early Universe, Boltzmann distribution, Neutrino decoupling temperature, Big-Bang Cosmology, Nucleosynthesis and baryon to photon ratio, Dark matter and its relic abundance, Baryogenesis, Phase transitions in early Universe, Inflationary Cosmology, Dark Energy, CMBR

EP4618 **2**
Quantum Field Theory

Canonical quantization, Complex scalar fields, Charge conservation, Charge conjugation, Feynman propagator, Dirac Equation, Quantization of Electromagnetic fields, Gauge invariance, Elements of quantum Electrodynamics. Feynman rules and Feynman diagram for spinor electrodynamics. Lowest order cross sections for electron-electron, electron-positron and electron-photon scattering. Elementary treatment of self-energy and radiative corrections, divergence and renormalization.

EP4628 **2**
Quantum Optics

Quantization of radiation filed, Coherent states, Quantum theory of Laser, Photon coherence, Statistical optics of Photons, Photon distribution of coherent and chaotic light, Quantum mechanical photon counting Distribution, Super radiance, Quantum beats, Squeezed states of light

EP4888 **2**
Introduction to String Theory
▷Undegraduate Mathematical Physics, Relativity. Quantum Mech.

Motivation for Strings, Relativistic Point particle: Classical and quantum, Bosonic strings: Nambu-Goto action, Old Covariant Light Cone quantization, Conformal Field Theory, RNS Superstrings, Compactification and T-duality: D-branes, Heterotic Strings, S-Duality and M-theory.
Pre-Req: Courses on Mathematical Physics, Relativity and Particle Physics

EP5118 **2**
Electronics

Introduction, Thevenin's Theorem, Norton's Theorem, Diode Theory, Rectifiers, Optoelectronics devices (LED, Photodiode, Laser Diode), Transistors and their frequency response (BJT, JFET, MOSFET,), Voltage and Power amplifiers, Differential Amplifiers, Operational amplifiers

EP5147 **1**
Classical Mechanics

Constraints, D'Alembert's principle, Lagrange's equation of first kind, generalized coordinates, Lagrange's equation of second kind, Hamilton's equation, connection to Newtonian physics.

EP5288 **1**
Digital Electronics

Binary digits, logic operations, number systems, logic gates, Boolean algebra, K-maps, combinational logic gates, functions of logic gates (adder, comparator etc), Flip flops and its applications (counters, shift registers, memory and storage)

Cover: The Fractal Academics at IIT Hyderabad is inspired by the fractals patterns that are self-similar across different scales. They are formed when similar patterns recur at progressively smaller & larger scales. The IITH logo seen on the cover is one such fractal curve formed through Hilbert filling of the space with variable densities.