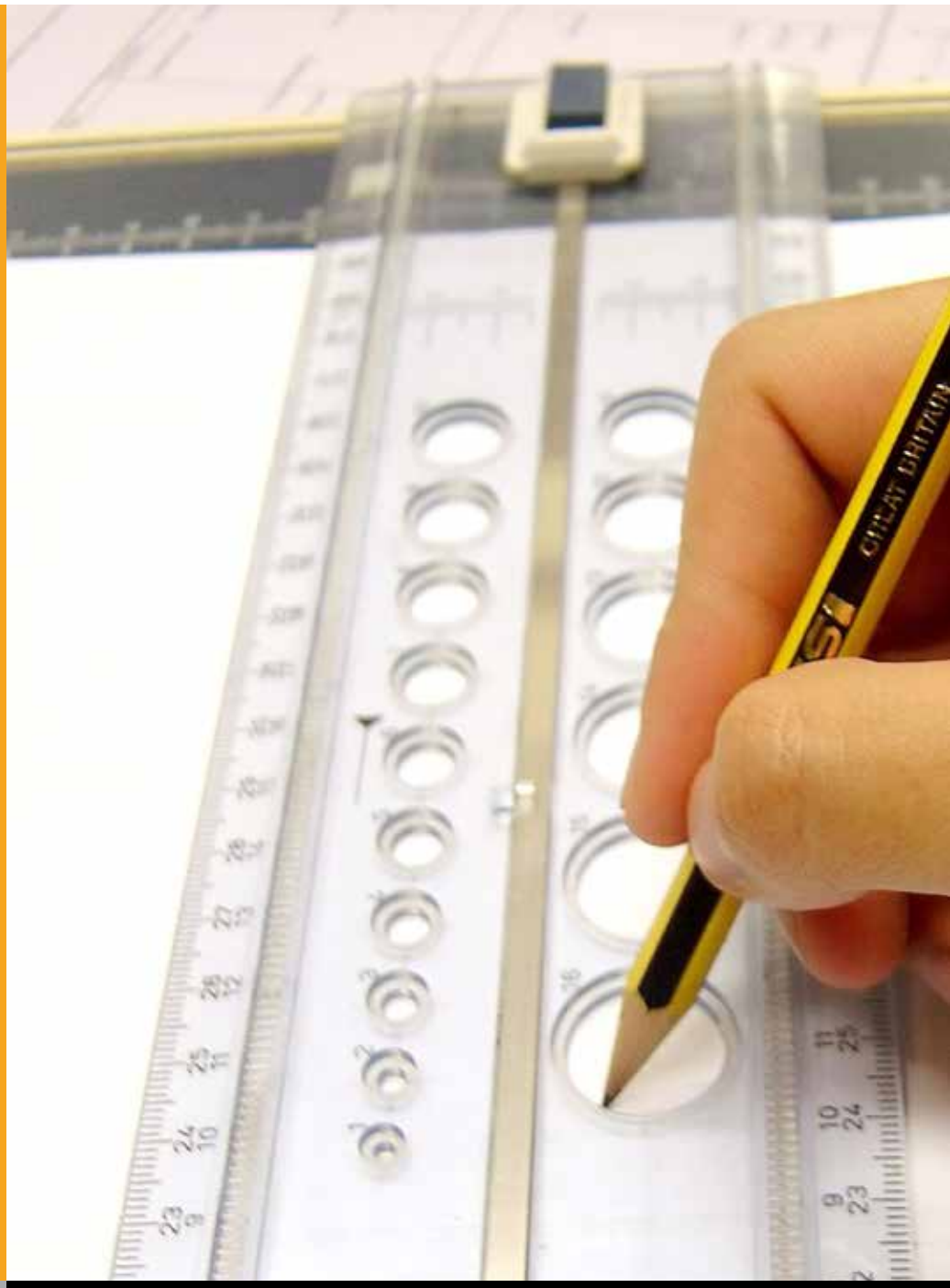
भारतीय प्रौद्योगिकी संस्थान हैदराबाद
Indian Institute of Technology Hyderabad

INDIAN INSTITUTE OF TECHNOLOGY
HYDERABAD

Fractal Academic Program



COURSE BOOKLET 2014-15

भारतीय प्रौद्योगिकी संस्थान हैदराबाद
Indian Institute of Technology Hyderabad

Course booklet for the batch 2014-15

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Introduction

भारतीय प्रौद्योगिकी संस्थान हैदराबाद
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Fractal Academics

Special thanks and gratefully acknowledge Prof. Raj Reddy of CMU for providing the core idea of fractional credit courses

Perceived Role of Higher Education

- Convey knowledge
- Create knowledge
- Create and develop ideas
- Innovations
- Publish
- Develop future citizens
- Create a better society
- …

Gradient

- Societal Gradient
- Rate of change in Society was very slow from 50s to 90s
- Since 90s, and in particular since 95 the rate of change has been phenomenal
- Gradient in Teaching Methods since 50s
- Very small
- Sure we use ppts and latest tech-gizmos, but that is not real change
- Complete mismatch between the two rates!

Changing Times

An Avalanche Is Coming, Higher Education and the Revolution Ahead by Michael Barber, Katelyn Donnelly, Saad Rizvi, March 2013

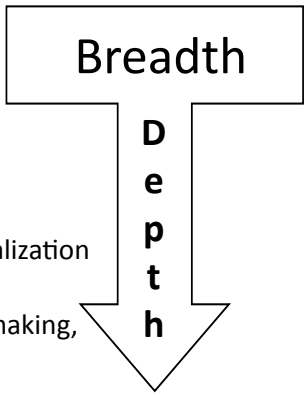
1. Does the curriculum need complete overhaul?
2. What are the right models of teaching and learning now that the traditional lectures are becoming less effective
3. Which students should be targeted?
4. Just as we've seen the forces of technology and globalization transform sectors such as media and communications or banking and finance over the last two decades, these forces may now transform higher education
5. The traditional university is being unbundled

Some More Questions (IIT Hyderabad)…

1. Why lack of motivations among students?
2. Why low attendance?
3. Why uneven student interest?
4. How to bridge the gulf between theory and practice?
5. How to bridge the gulf between breadth and depth?
6. What is the relevance of non-core subjects?
7. How to have a flexible curriculum?
8. How to space the curriculum based on individual potential?
9. How to make the curriculum interdisciplinary?
10. How to increase industry interactions?
11. How to incorporate research in under graduate curriculum?
12. Has the 3 credit hour system outlived its utility?

Philosophy: The new program should capture…

- T-Education
- Breadth with Depth
- Flexibility
- Foster Interdisciplinarity
- Wider choice of electives
- Foster Research at undergraduate level
- Synergy in projects – hopefully leading to products
- Students can pace their program
- Greater choice for knowledge acquisition and specialization
- Encourage creativity
- Bouquet of courses in Creative Arts (Music, Movie making,
- fine arts, photo journalism, performing arts, etc.)
- Facilitate industry interactions



Initial Attempts: Fractional Credit Courses

- A typical 3 lecture course has 3 credits leading to 42 lecture hours in a semester.
- Fractional credits can be 0.5, 1, 1.5, 2.0, 2.5, 3.0 having 7, 14, 21, 28, 35 and 42 lectures hours respectively.
- Some examples of fractional credit courses (1 credit) that were offered at IITH:
  - Trends in Storage Systems (by NetApp)
  - Mobile Applications (by Adobe)
  - Data Management and Computing on the Cloud
  - Empowering Three Billion (taught by former President Dr. Kalam)
  - Finance and Economy
  - Sales and Marketing
  - Photo Journalism
  - Movie Making
  - Drama (Performing Arts)
  - Courses by Visiting Faculty in Math and EE from USA
  - Course in Material Science by visiting faculty from France
  - …

Minor in Entrepreneurship – Unique Program at IITH

S.No.	Course Name	Credits	Instructor	Semester
Semester 3.1				
1	Introduction to Finance and Economy	1	Sri Nagesh	3rd Year, 1st Semester
2	Introduction to Sales and Marketing	1	J. P. Sahu	3rd Year, 1st Semester
3	Introduction to Entrepreneurship	1	Ajai Chowdhry	3rd Year, 1st Semester
Semester 3.2				
4	Strategic Innovative Entrepreneurship	1	Ramesh Loganathan	3rd Year, 2nd Semester
5	Introduction to Business plan	1	Satish Andra / Srini Adepallli	3rd Year, 2nd Semester
6	Early Customer Acquisition and Relationship Management	1	Santanu Paul	3rd Year, 2nd Semester
Semester 4.1				
7	Business Plan Development (Project)	3	Murali Bukkapatnam and IITH Faculty	4th Year, 1st Semester
Semester 4.2				
8	HR and Leadership	1	B. V. R. Mohan Reddy	4th Year, 2nd Semester
9	Company Valuation	1	Hemant Kanakia	4th Year, 2nd Semester
10	Risk Management	1	Pradeep Mittal	4th Year, 2nd Semester
Total Credits		12		

Fractal Academic Program: Novel Program Launched at IITH

- In Aug 2013 launched in Electrical Engineering
- Aug. 2014 for all B.Tech. Programs
- Aug 2014, some M.Tech. Programs (Integrated Design and Manufacturing)
- **Courses of 0.5, 1, 1.5, 2, 2.5 etc. credits**
- Departmental courses in the very first year
- Inherently Multidisciplinary
- Promotes R and D from an early stage
- Courses in Liberal Arts
- Courses in Creative Arts
  - Incorporates the Design Spine
- Holistic Education

Basic Building Blocks

- Atomize the courses and programs
  - 1 credit courses for breadth
- Core courses
- 1.5, 2, 2.5 credit courses for depth
  - Specialized courses
  - Electives
  - Projects and building prototypes / products
  - Bridging gulf between theory and practice

1 Credit Courses…

- All core courses
- Helps interdisciplinary education
- Open to all students – allows for greater breadth
- Students have the option of greater number of interesting courses
- Allows students to better tailor their coursework and choose across Departments
- Large basket of non-technical courses (LA – Liberal Arts + CA-Creative Arts)
- Better access to a wide variety of courses increases exposure and preparedness for research
- Synergy in projects - foundation for product development
- A balance is sought between technical and non-technical courses to reduce stress when students enter IIT Hyderabad
- The first two semesters expose students to all the basic tools required for the rest of their Bachelors program
- *The curriculum potentially makes students ready for internship right after the first year*

Outside Specialization Courses (Partial List)

- Photography
- Entrepreneurship
- Movie making
- Western classical music
- Drama
- Life science concepts
- Music and mathematics
- Space program
- Efficiency vs goodness
- Healthcare and technology
- Teamwork and collaboration
- …
- Managing failure
- Deconstructing design
- Hindustani classical music
- Fine arts
- Basics of vision
- History of math
- History of science
- Carnatic classical music
- Linguistic abilities
- Personal Effectiveness
- Science, Society and Culture
- …

Science and Technology Breadth Courses (Partial List)

- Genomics
- Brain and cognition
- Big data
- Logic
- Philosophy
- Molecular Communication
- Drug delivery
- Energy Storage Technologies
- …
- Future Cities
- Singularities in Science and Technologies
- Semantic Web
- Future Materials
- Water
- Engineering in Biology
- …

Illustrative Fractal Program in Electrical Engineering at IITH

Semester 1 Courses (Credits) Total Credits: 18	Duration 1/6	2/6	3/6	4/6	5/6	6/6
1. Independent Project (1)	←	—	—	—	—	→
2. Digital Fabrication (2)	←	—	—	—	—	→
3. Introduction to Programming (1)	←	—	—	—	—	→
4. Introduction to Programming Lab (2)	←	—	—	—	—	→
5. Calculus – I (1)	←	—	→			
6. Calculus – II (2)			←	—	—	→
7. Classical Physics (1)			←	—	→	
8. Boolean Algebra (1)	←	—	→			
9. Electric Circuits (1)			←	—	→	
10. Magnetic Circuits (1)					←	→
11. Signals and Communications (1)					←	→
12. Bioengineering (1)			←	—	→	
13. Liberal Arts Elective (1)	←	—	→			
14. Creative Arts Elective (1)			←	—	→	
15. Free Elective 1 (1)					←	→

Each Semester Partitioned into 6 Segments each representing 0.5 credit

Semester 2 Courses (Credits) Total Credits: 19	Duration					
	1/6	2/6	3/6	4/6	5/6	6/6
1. Independent Project (1)	←	—	—	—	—	→
2. Vector Calculus (1)	←	—	→			
3. Differential Equations (1)					←	→
4. EM and Maxwell's Equations (1)			←	→		
5. Introduction to Data Structures (1)	←	—	—	→		
6. Introduction to Data Structures Lab (2)	←	—	—	→		
7. Matrix Analysis (2)	←	—	—	—	—	→
8. Data Analytics (2)			←	—	—	→
9. Basic Control Theory (1)	←	→				
10. Digital Signal Processing (1)			←	→		
11. Semiconductor Fundamentals (1)					←	→
12. Embedded Programming (1)					←	→
13. Physiology for Engineers (1)	←	→				
14. Liberal Arts Elective (1)	←	→				
15. Creative Arts Elective (1)			←	→		
16. Free Elective 1 (1)					←	→

Semester 3 Courses (Credits) Total Credits: 20	Duration					
	1/6	2/6	3/6	4/6	5/6	6/6
1. EE Independent Project/Free Elective (1)	←	—	—	—	—	→
2. Computer Organization (1)					←	→
3. Science Elective (1)			←	→		
4. Environmental Chemistry – I (1)	←	→				
5. Chemistry Lab (2)	←	—	—	—	—	→
6. Device Physics (2)	←	—	—	→		
7. Linear Electronics (1)			←	→		
8. Digital Systems and Design (1)			←	—	—	→
9. Digital Modulation Techniques (1)	←	→				
10. Information Science (1)	←	→				
11. Advanced DSP (2)			←	—	—	→
12. Transformers and DC Machines (2)			←	—	—	→
13. Graph Theory (1)	←	→				
14. Antenna Design (1)			←	→		
15. Liberal Arts Elective (1)	←	→				
16. Creative Arts Elective (1)			←	→		
17. Free Elective 1 (1)					←	→

Semester 4 Courses (Credits) Total Credits: 20	Duration					
	1/6	2/6	3/6	4/6	5/6	6/6
1. EE Independent Project (1)	←	—	—	—	—	→
2. Complex Variables (1)			←	→		
3. Science Elective (1)					←	→
4. Renewable Energy and Power Systems (1)	←	→				
5. Smart Grid (1)			←	→		
6. Optimization (1)			←	—	—	→
7. AC Machines (1)					←	→
8. Power Electronics (1)			←	→		
9. Introduction to Multimedia (1)	←	→				
10. Channel Coding (1)					←	→
11. Advanced Analog Electronics (2)	←	—	—	→		
12. Embedded Systems (1)					←	→
13. CMOS Fabrication (1)			←	→		
14. Control Systems (1)	←	→				
15. Computer Networks (1)					←	→
16. Thin Films and Devices (1)	←	→				
17. Liberal Arts Elective (1)	←	→				
18. Creative Arts Elective (1)			←	→		
19. Free Elective 4 (1)					←	→

Semester 5 Courses (Credits) Total Credits: 19	Duration					
	1/6	2/6	3/6	4/6	5/6	6/6
1. EE Independent Project (1)	←	—	—	—	—	→
2. Science Elective (2)	←	—	—	→		
3. Engineering Elective (2)			←	—	—	→
4. Random Processes (2)	←	—	—	→		
5. Power Electronics Analysis and Design (1)	←	→				
6. Digital Chip Design (2)			←	—	—	→
7. Core Elective 1 (2)	←	—	—	→		
8. Core Elective 5 (2)			←	—	—	→
9. Electrical Machines Lab (2)	←	—	—	—	—	→
10. Liberal Arts Elective (1)	←	→				
11. Creative Arts Elective (1)			←	→		
12. Free Elective 5 (1)					←	→

Semester 6 Courses (Credits) Total Credits: 19	Duration					
	1/6	2/6	3/6	4/6	5/6	6/6
1. EE Independent Project (1)	←	—	—	—	—	→
2. Science Elective (2)	←	—	—	—	→	
3. Engineering Elective (2)			←	—	—	→
4. Power Systems Practice (2)			←	—	—	→
5. Cellular Networks (1)	←	→				
6. Core Elective 3 (2)	←	—	—	→		
7. Core Elective 4 (2)			←	—	—	→
8. Core Elective 5 (2)	←	—	—	→		
9. VLSI Lab (2)	←	—	—	—	—	→
10. Liberal Arts Elective (1)	←	→				
11. Creative Arts Elective (1)			←	→		
12. Free Elective 6 (1)					←	→

Semester 7 Courses (Credits) Total Credits: 15	Duration					
	1/6	2/6	3/6	4/6	5/6	6/6
1. EE Independent Project (3)	←	—	—	—	—	→
2. Core Elective 6 (2)	←	—	—	→		
3. Core Elective 7 (2)			←	—	—	→
4. Core Elective 8 (2)	←	—	—	→		
5. Liberal Arts Elective (1)	←	→				
6. Creative Arts Elective (1)			←	→		
7. Free Elective 7 (2)	←	—	—	→		
16. Free Elective 8 (2)			←	—	—	→

Semester 8 Courses (Credits) Total Credits: 15	Duration					
	1/6	2/6	3/6	4/6	5/6	6/6
1. EE Independent Project (3)	←	—	—	—	—	→
2. Core Elective 9 (2)	←	—	—	→		
3. Core Elective 10 (2)			←	—	—	→
4. Core Elective 11 (2)	←	—	—	→		
5. Liberal Arts Elective (1)	←	→				
6. Creative Arts Elective (1)			←	→		
7. Free Elective 9 (2)	←	—	—	→		
16. Free Elective 10 (2)			←	—	—	→

Fractal Program in M.Tech. Integrated Design and Manufacturing

SEMESTER – I	
Course Name	Credits
Mathematical Methods for Engineers	3
Elasticity and Plasticity	1.5
Fluid Mechanics and Heat Transfer	1.5
Computational Fluid Dynamics (CFD) Tools (Theory + Lab)	1.5
Finite Element Methods: Theory	3
Finite Element Methods: Lab	1
Material Science and Material Selection	1.5
Manufacturing Processes	2
Design for Manufacturability and Assembly	1
Scaling Laws and Multi-scale Manufacture	1
Total	**17**

SEMESTER – II	
Course Name	Credits
Mathematical Elements for Geometrical Modeling	1.5
Computer Integrated Manufacturing	1.5
Process Control and Optimization	1.5
Artificial Intelligence	1.5
Choose one from: (1) Material Removal Processes (2) Material Joining Processes (3) Material Forming Processes	3
Integrated Design and Manufacturing Lab	2
Core Electives	3
Free Electives	1
Total	**15**

SEMESTER – III		
	Course Name	Credits
ME6106	Seminar Course	1
ME6005	Thesis (Stage1)	14
	Total	**17**

SEMESTER – IV		
	Course Name	Credits
ME6106	Seminar Course	1
ME6005	Thesis (Stage1)	14
	Total	**17**

Total Number of Credits: 62

List of Core Electives for Integrated Design and Manufacturing	
Course Name	Credits
Automation and Robotics	1
Management of Manufacturing Systems	1
Additive Manufacturing	1
Micro-Manufacturing	1
Measurement Science and Techniques	1
Plastic Part Manufacture and Design	1
Reliability and Fault Diagnostics	1
Fatigue, Fracture and Life Cycle Estimation	2
Precision Machine Design*	2
Phase Change Phenomenon*	1

Strength and Challenges of Fractal Academics

Strengths	Challenges
Foster Creativity	
Better exposure to larger number of topics	
More flexibility in breadth and depth	Perhaps spreading too thin / losing focus?
Foster Interdisciplinary education and undergraduate research	Context switching / distracting?
Easier implementation of fast and slow track program	
All round development - Holistic education	

Concluding Remarks

- Trying something innovative is imperative -- of course it will involve some calculated risks
- The fractal academic program is innovative and evolutionary
- Strong belief that Fractal Academics will inculcate the spirit of innovation and fetch desired results
- We believe atomization of the academic program a must

1.1. Departments

The Institute is organised into the following departments:

- Department of Biomedical Engineering
- Department of Biotechnology
- Department of Chemical Engineering
- Department of Chemistry
- Department of Civil Engineering
- Department of Computer Science and Engineering
- Department of Design
- Department of Electrical Engineering
- Department of Engineering Science
- Department of Liberal Arts
- Department of Materials Science and Metallurgical Engineering
- Department of Mathematics
- Department of Mechanical and Aerospace Engineering
- Department of Physics

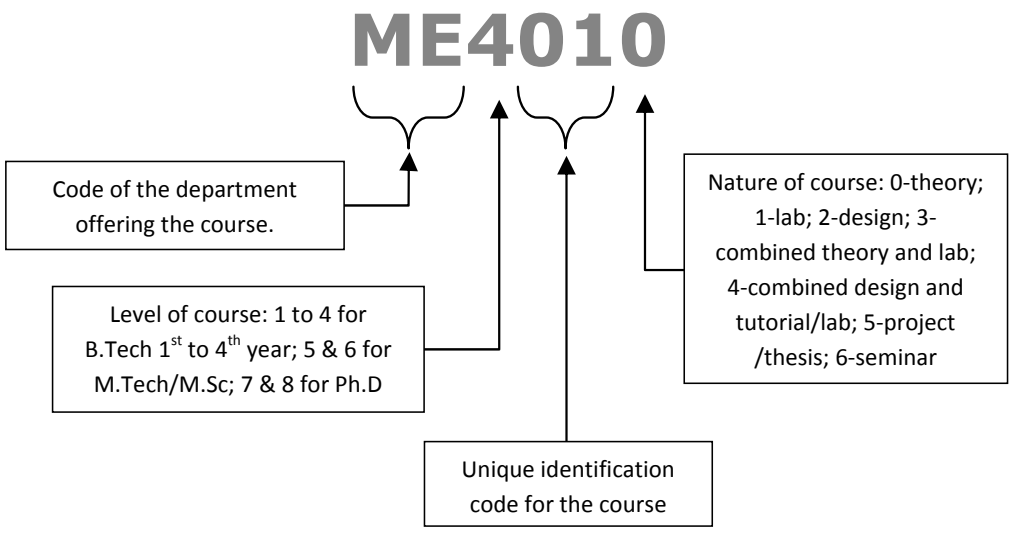
1.2. Academic Programs

The Institute is running the following Degree Programs based on Fractal Academic System:

- **B.Tech. Programs (4 Year, Fractal Academic Program)**
  - Civil Engineering
  - Chemical Engineering
  - Computer Science and Engineering
  - Electrical Engineering
  - Engineering Physics
  - Engineering Science
  - Materials Science and Metallurgical Engineering
  - Mechanical Engineering
- **M.Tech. Programs (2 Year, Fractal Academic Program)**
  – Chemical Engineering
  - Mechanical Engineering: Integrated Design and Manufacturing

1.4. Course numbering scheme

Normally, every course at IIT Hyderabad runs for the full length of the semester. Each course is denoted by six alpha-numerals course number, two alphabets followed by four numerals:



IIT Hyderabad

4 Year
B.Tech. Programs

CIVIL ENGINEERING

Course No	Course Name	Credits	A full Semester					
			Time Segments when it runs					
			1/6	2/6	3/6	4/6	5/6	6/6
SEM – 1								
ID1035	Independent Project	1						
MA1110	Calculus-I	1						
ID1200	Introduction to Programming	1						
CY1017	Environmental Chemistry-I	1						
ID1130	Engineering Statics	2						
ID1100	Fluid Mechanics-I	2						
ID1201	Introduction to Programming (Lab)	2						
ID1054	Digital Fabrication	2						
ID1041	Engineering Drawing	2						
ID1081	Fabrication Lab	2						
Laxxxx	Liberal and Creative Arts Electives	2						
		18						
SEM – 2								
MA1140	Linear Algebra	1						
MA2140	Statistics	1						
CY1027	Dynamics of Chemical Systems-I	1						
ID1160	Solid Mechanics-I	2						
CE2011	Solid Mechanics Lab	1						
ME1020	Dynamics	2						
ID1140	Thermodynamics-I	1						
ID1091	Fabrication Lab-II	2						
CE2020	Construction Materials	1.5						
CE3512	Introduction to Environmental Engineering	1						
Laxxxx	Liberal and Creative Arts Electives	2						
		15.5						
SEM – 3								
MA1220	Calculus-II	2						
PH1017	Classical Physics	1						
PH1031	Physics Lab	2						
CY1031	Chemistry Lab	2						
ID2020	Solid Mechanics-II	2						
ID1110	Fluid Mechanics-II	1.5						
EE1010	Electric Circuits	1						
EE1020	Magnetic Circuits	1						
Ce2021	Construction Materials Lab	2						
CE2031	Fluid Mechanics Lab	1						
Ce3102	Introduction to Reinforced Concrete	1.5						
CE2030	Concrete Technology	1.5						
MA2120	Transforms	1						
MA2110	Probability	1						

Course No	Course Name	Credits	A full Semester					
			Time Segments when it runs					
			1/6	2/6	3/6	4/6	5/6	6/6
Laxxxx	Liberal and Creative Arts Electives	2						
		22.5						
SEM – 4								
MA2130	Complex Variables	1						
MA1150	Differential Equations	1						
MA1130	Vector Calculus	1						
PH1027	EM and Maxwells Equation	1						
CY1021	Dynamics of Chemical Systems-II	2						
ID1150	Thermodynamics–II	2						
BO1010	Introduction to Life Sciences	1						
Laxxxx	Liberal and Creative Arts Electives	2						
CE2100	Introduction to Structural Analysis	1.5						
CE2110	Analysis of Indeterminate Structures	1.5						
CE3300	Geotechnical Engineering-I	1.5						
CE3310	Geotechnical Engineering-II	1.5						
CE3301	Geotechnical Engineering Lab	2						
CE2101	Structural Mechanics Lab	2						
CE3112	Introduction to Structural Steel Design	1.5						
		22.5						
SEM – 5								
CE3312	Introduction to Foundation Engineering	1						
CE3322	Design of Foundations	2						
CE3122	Reinforced Concrete Design	1.5						
CE3522	Water and Waste Water Engineering	2						
CE3500	Introduction to Hydraulic Engineering	1.5						
CE3800	Transportation Engineering–I	3						
CE3010	Fundamentals of GIS and Remote Sensing	2						
CE3011	GIS Lab	1						
PH	Physics Elective	1						
Laxxxx	Liberal/Creative Arts	2						
BIO	Bio-engineering	1						
PH	Physics Elective	1						
EE2511	Basic Electrical Engineering Lab	2						
PH3317	Thermal Physics	1						
		22						
SEM – 6								
CE3510	Open Channel Hydraulics	1.5						
CE3501	Hydraulic Engineering Lab	1						
CE2500	Engineering Hydrology	2						
CE3511	Environmental Engineering lab	2						
CE3005	Project 1	3						
CE3132	Design of Steel Structures	1.5						

Course No	Course Name	Credits	A full Semester					
			Time Segments when it runs					
			1/6	2/6	3/6	4/6	5/6	6/6
CE3810	Transportation Engineering-II	3						
EE1300	DSP	1						
Laxxxx	Liberal/Creative Arts	2						
		17						
SEM – 7								
Cexxxx	Core Elective-I	3						
Cexxxx	Core Elective-II	3						
CE4502	Water Resources Engineering	2						
CE4900	Construction Management	3						
CE3020	Surveying	2						
Laxxxx	Liberal/Creative Arts	2						
		15						
SEM - 8								
Cexxxx	Core Elective-III	3						
Cexxxx	Core Elective-IV	3						
LAxxxx	Professional Ethics	2						
XXXXX	Free Electives	6						
		14						

CHEMICAL ENGINEERING

Course No	Course Name	Credits	A full Semester					
			Time Segments when it runs					
			1/6	2/6	3/6	4/6	5/6	6/6
SEM - 1								
MA1110	Calculus-I	1						
MA1220	Calculus-II	2						
CY1017	Environmental Chemistry-I	1						
PHxxxx	Physics Elective	1						
ID1035	Independent Project	1						
CH1010	Material and Energy Balance	2						
CY1031	Chemistry Lab	2						
PH1031	Physics Lab	2						
ID1054	Digital Fabrication	2						
ID1081	Fabrication Lab I	2						
LAXXX	LA-1/CA-I	2						
	Total	18						
SEM-2								
PHxxxx	Physics Elective	1						
MA1130	Vector Calculus	1						
CY1027	Dynamics of Chemical Systems-I	1						
MA1140	Linear Algebra	1						
MA1150	Differential Equations	1						
ID1140	Thermodynamics-I	1						
ID1150	Thermodynamics-II	2						
CH1060	Solids Handling and Comminution	1						
CE????	Introduction to Environmental Engineering	1						
CH1080	Engineering Materials	1						
CH1100	Sustainable Energy	1						
CH1120	Chemical Technology	1						
CH1140	Interfacial Chemistry	1						
CH1021	Chemical Engineering Lab	2						
LAXXX	LA-2/CA-2	2						
	Total	18						
SEM - 3								
MA2120	Transforms	1						
MA2110	Probability	1						
CY1030	Environmental Chemistry-II	2						
CH2010	Principles of Mass Transfer	1						
CH2050	Mechanical Seperation	2						
ID1100	Fluid Mechanics-I	2						
CH2070	Numerical Methods-I	2						
ID1041	Engineering Drawing	2						
ID1200	Introduction to Programming	1						
ID1201	Introduction to Programming (lab)	2						

Course No	Course Name	Credits	A full Semester					
			Time Segments when it runs					
			1/6	2/6	3/6	4/6	5/6	6/6
CH2011	Applied Chemistry Lab	2						
LAXXX	LA-3/CA-3	2						
	Total	20						
SEM - 4								
CY1021	Dynamics of Chemical Systems-II	2						
MA2130	Complex Variables	1						
MA2140	Statistics	1						
CH2020	Gas-Liquid Operations	2						
CH2040	Chemical Reaction Engineering	2						
CH2060	Non Ideal Reactors	1						
CH2080	Transportation and Mixing of Fluids	1						
CH2100	Modes of Heat Transfer	2						
EE1220	Basic control theory	1						
CH2120	Heat Transfer Equipments	1						
CH2140	Numerical Methods-II	2						
CH2160	Petrochemical Industry	1						
CH2021	Fluid Mechanics and Mechanical Operations Lab	2						
LAXXX	LA-4/CA-4	2						
	Total	21						
SEM -5								
CH3010	Liquid-Liquid and Solid-Liquid Operations	2						
CH3030	Chemical Engineering Thermodynamics-I	2						
CH3050	Non Isothermal Reactors	2						
CH3070	Transport Phenomena-I	2						
CH3090	Heat Transfer Equipment Design	1						
CH3110	Control Design and Analysis	2						
CH3130	Optimization Techniques-I	2						
LAxxxx	LA-5/CA-5	2						
CE3512	Water and Waste Water Engineering	2						
CH3011	Heat Transfer and Mass Transfer Lab	2						
	Total	19						
SEM - 6								
CH3020	Mass transfer equipment design	2						
CH3040	Heterogeneous Reaction Engineering	1						
CH3060	Transport Phenomena-II	2						
CH3080	Polymer Engineering	1						
CH3100	Optimization-II	1						
CH3120	Cell Dynamics	1						
CH3140	Bio-molecular kinetics	1						
CH3160	Bio-refinery	1						
CH3180	Introduction to Nanotechnology	1						

Course No	Course Name	Credits	A full Semester					
			Time Segments when it runs					
			1/6	2/6	3/6	4/6	5/6	6/6
CH3300	Distillation	2						
CH3021	Reaction Engineering and Process Control Lab	2						
Laxxxx	LA-6/CA-6	2						
	Total	17						
SEM – 7								
CH4010	Chemical Engineering Thermodynamics-II	1						
CH4030	Process Plant Design	2						
CH4050	Bio-Mechanics	1						
CH4016	Seminar	1						
CH4011	Process Simulation Lab	2						
	LA-7/CA-7	2						
	Total	9						
SEM - 8								
CH4020	Air Pollution	1						
CH4040	Process Intensification	1						
CH4060	Safety and Hazards	1						
	Professional Ethics	2						
	Total	5						

COMPUTER SCIENCE AND ENGINEERING

Course No	Course Name	Credits	A full Semester					
			Time Segments when it runs					
			1/6	2/6	3/6	4/6	5/6	6/6
SEM – 1								
ID1035	Independent Project	1						
MA1110	Calculus-I	1						
MA1220	Calculus-II	2						
PH1017	Classical Physics	1						
CY1017	Environmental Chemistry-I	1						
CY1031	Chemistry Lab	2						
ID1054	Digital Fabrication	2						
ID1200	Introduction to Programming	1						
ID1201	Introduction to Programming Lab	2						
EE1110	Boolean Algebra	1						
CS1210	Proof Techniques	1						
CS1220	Automata Theory	1						
Laxxxx	Liberal and Creative Arts Electives	2						
SEM – 2								
MA1130	Vector Calculus	1						
MA1140	Linear Algebra	1						
PH1027	EM and Maxwells Equation	1						
CY1027	Dynamics of Chemical Systems-I	1						
BO1010	Introduction to Life Sciences	1						
CS1230	Introduction to Data Structures	2						
CS1231	Introduction to Data Structures Lab	2						
CS1240	Software Engineering-I	1						
CS1250	Combinatorics	2						
CS1260	Graph Theory	1						
CS1270	Introduction to Database Management Systems	1						
CS1271	Introduction to Database Management Systems Lab	1						
CS1280	Introduction to Operating Systems	1						
Laxxxx	Liberal and Creative Arts Electives	2						
XXxxxx	Free Electives	1						
SEM – 3								
MA2110	Probability	1						
PHxxxx	Physics (electives)	2						
PH1031	Physics Lab	2						
EE2120	Computer Organization	1						
EE2110	Digital Systems and Design	1						
CS2230	Data Structures	2						
CS2231	Data Structures Lab	2						
CS2280	Operating Systems	2						
CS2281	Operating Systems Lab	2						
CS2210	Theory of Computation-I	1						

Course No	Course Name	Credits	A full Semester					
			Time Segments when it runs					
			1/6	2/6	3/6	4/6	5/6	6/6
CS2250	Computer Networks-I	1						
CS2200	Algorithms-I	1						
Laxxxx	Liberal and Creative Arts Electives	2						
XXxxxx	Free Electives (total 1 for 3 and 4 sems)	0-1						
SEM – 4								
PHxxxx	Physics (elective)	1						
CS2330	Logic	1						
CS2310	Theory of Computation-II	2						
CS2350	Computer Networks-II	2						
CS2351	Computer Networks-II Lab	2						
CS2300	Algorithms-II	2						
CS2370	Database Management Systems Internals	2						
CS2371	Database Management Systems Internals Lab	2						
CSxxxx	Department Elective	1						
Laxxxx	Liberal and Creative Arts Electives	2						
XXxxxx	Free Electives (total 1 for 3 and 4 sems)	0-1						
SEM – 5								
MA2120	Transforms	1						
BM1030	Bio-Engineering	1						
CS3303	Software Technologies	2						
CS3320	Compilers-I	1						
CS3321	Compilers-I Lab	1						
CS3340	Principles of Programming Languages-I	1						
CS3360	Distributed Computing-I	1						
CSxxxx	Department Electives	7						
Laxxxx	Liberal and Creative Arts Electives	2						
XXxxxx	Free Electives	2						
SEM – 6								
CS3420	Compilers-II	2						
CS3421	Compilers-II Lab	1						
CS3440	Principles of Programming Languages-II	2						
CS3460	Distributed Computing-II	2						
CS3480	Linear Optimization-I	1						
CS3405	Mini-Project-I	2						
CSxxxx	Department Electives	5						
Laxxxx	Liberal and Creative Arts Electives	2						
XXxxxx	Free Electives	2						
SEM – 7								
CS4440	Software Engineering-II	1						

Course No	Course Name	Credits	A full Semester					
			Time Segments when it runs					
			1/6	2/6	3/6	4/6	5/6	6/6
CS4441	Software Engineering-II Lab	2						
CS4480	Linear Optimization-II	2						
CS4405	Mini-Project-II	2						
CSxxxx	Department Electives	5						
Laxxxx	Liberal and Creative Arts Electives	2						
XXxxxx	Free Electives	2						
SEM - 8								
CSxxxx	Department Electives	10						
LAxxxx	Professional Ethics	1						
LAxxxx	Liberal and Creative Arts (Professional Ethics)	2						
XXxxxx	Free Electives	3						

ELECTRICAL ENGINEERING

Course No	Course Name	Credits	A full Semester					
			Time Segments when it runs					
			1/6	2/6	3/6	4/6	5/6	6/6
SEM – 1								
ID1035	Independent Project	1						
ID1054	Digital Fabrication	2						
ID1200	Introduction to Programming	1						
ID1201	Introduction to Programming Lab	2						
MA1110	Calculus-I	1						
MA1220	Calculus-II	2						
PH1017	Classical Physics	1						
EE1110	Boolean Algebra	1						
EE1010	Electric Circuits	1						
EE1020	Magnetic Circuits	1						
EE1320	Signals and Communications	1						
BM1030	Bio-engineering	1						
Laxxxx	Liberal Arts Elective	1						
Caxxxx	Creative Arts Elective	1						
XXxxxx	Free Elective 1	1						
	Total credits	18						
SEM – 2								
EE1025	EE Independent Project	1						
MA1130	Vector Calculus	1						
MA1150	Differential Equations	1						
PH1027	EM and Maxwells Equation	1						
CS1230	Introduction to Data Structures	1						
CS1231	Introduction to Data Structures Lab	2						
EE1510	Matrix Analysis	2						
EE1310	Data Analytics	2						
EE1220	Basic Control Theory	1						
EE1300	DSP	1						
EE1080	Semiconductor Fundamentals	1						
EE1170	Embedded programming	1						
BM1040	Physiology for Engineers	1						
Laxxxx	Liberal Arts Electives	1						
Caxxxx	Creative Arts Electives	1						
XXxxxx	Free Elective 2	1						
	Total credits	19						
SEM – 3								
EE2015/ XXxxx	EE Independent Project/Free Elective 3	1						
EE2120	Computer Organization	1						
XXxxxx	Science Elective	1						
CY1017	Environmental Chemistry – I	1						
CY1031	Chemistry Lab	2						

Course No	Course Name	Credits	A full Semester					
			Time Segments when it runs					
			1/6	2/6	3/6	4/6	5/6	6/6
EE2010	Device Physics	2						
EE2020	Linear Electronics	1						
EE2110	Digital Systems and Design	1						
EE2320	Digital Modulation Techniques	1						
EE2310	Information Science	1						
EE2300	Advanced DSP	2						
EE2200	Transformers and DC Machines	2						
EE2510	Graph Theory	1						
EE2090	Antenna Design	1						
Laxxxx	Liberal Arts Elective	1						
Caxxxx	Creative Arts Elective	1						
	Total credits	20						
SEM – 4								
EE2025	EE Independent Project	1						
MA2130	Complex Variables	1						
XXxxxx	Science Elective	1						
EE2240	Renewable Energy and Power Systems	1						
EE2230	Smart grid	1						
EE2250	Optimization	1						
EE2260	AC Machines	1						
EE2210	Power Electronics	1						
EE2360	Introduction to Multimedia	1						
EE2380	Channel Coding	1						
EE2130	Advanced Analog Electronics	2						
EE2160	Embedded Systems	1						
EE2140	CMOS Fabrication	1						
EE2220	Control Systems	1						
EE2520	Computer Networks	1						
EE2150	Thin Films and Devices	1						
Laxxxx	Liberal Arts Electives	1						
Caxxxx	Creative Arts Electives	1						
XXxxxx	Free Elective 3	1						
	Total credits	20						
SEM – 5								
EE3015	EE Independent Project	1						
XXxxxx	Science Elective	2						
XXxxxx	Engineering Elective	2						
EE3310	Random Processes	2						
EE3210	Power Electronics Analysis and Design	1						
EE3030	Digital Chip Design	2						
Eexxxx	Core Elective 1	2						

Course No	Course Name	Credits	A full Semester					
			Time Segments when it runs					
			1/6	2/6	3/6	4/6	5/6	6/6
Eexxxx	Core Elective 2	2						
EE3041	Electrical Machines Lab	2						
Laxxxx	Liberal Arts Elective	1						
Caxxxx	Creative Arts Elective	1						
XXxxxx	Free Elective 4	1						
	Total credits	19						
SEM – 6								
EE3025	EE Independent Project	1						
XXxxxx	Science Elective	2						
XXxxxx	Engineering Elective	2						
EE3240	Power Systems Practice	2						
EE3320	Cellular Networks	1						
Eexxxx	Core Elective 3	2						
Eexxxx	Core Elective 4	2						
Eexxxx	Core Elective 5	2						
EE3041	Lab (VLSI)	2						
Laxxxx	Liberal Arts Electives	1						
Caxxxx	Creative Arts Electives	1						
XXxxxx	Free Elective 5	1						
	Total credits	19						
SEM – 7								
EE4015	EE Independent Project	3						
Eexxxx	Core Elective 6	2						
Eexxxx	Core Elective 7	2						
Eexxxx	Core Elective 8	2						
Laxxxx	Liberal Arts Elective	1						
Caxxxx	Creative Arts Elective	1						
XXxxxx	Free Elective 6	2						
XXxxxx	Free Elective 7	2						
	Total credits	15						
SEM - 8								
EE4025	EE Independent Project	3						
EExxxx	Core Elective 9	2						
EExxxx	Core Elective 10	2						
EExxxx	Core Elective 11	2						
LAxxxx	Liberal Arts Electives	1						
CAxxxx	Creative Arts Electives	1						
XXxxxx	Free Elective 8	2						
XXxxxx	Free Elective 9	2						
	Total credits	15						
	Total credits - all semesters	145						

ENGINEERING PHYSICS

Course No	Course Name	Credits	A full Semester					
			Time Segments when it runs					
			1/6	2/6	3/6	4/6	5/6	6/6
SEM – 1								
ID1054	Digital Fabrication	2						
ID1035	Independent Project	1						
MA1110	Calculus-I	1						
MA1220	Calculus-II	2						
PH1017	Classical Physics	1						
ID1200	Introduction to Programming	1						
ID1201	Introduction to Programming (Lab)	2						
EE1010	Electric Circuits	1						
EE1020	Magnetic Circuits	1						
EE1110	Boolean Algebra	1						
CY1031	Chemistry Lab	2						
CY1017	Environmental Chemistry-I	1						
Laxxxx	Liberal and Creative Arts Electives	2						
		18						
SEM – 2								
MA1130	Vector Calculus	1						
MA1140	Linear Algebra	1						
MA1150	Differential Equations	1						
PH1027	Electro Magnetism and Maxwells Equation	1						
CY1027	Dynamics of Chemical Systems-I	1						
BO1010	Introduction to Life Sciences	1						
CS1270	Introduction Data Base Management System	1						
CS1271	Introduction Data Base Management System (Lab)	1						
CS1230	Introduction to Data Structures	1						
CS1231	Introduction to Data Structures (Lab)	2						
CS1280	Introduction to Operating System	1						
EE1170	Embedded programming	1						
XXxxxx	Free Elective	1						
XXxxxx	Free Elective	1						
Laxxxx	Liberal and Creative Arts Electives	2						
		17						
SEM – 3								
CS2230	Data Structures	2						
CS2231	Data structure (Lab)	2						
CS2250	Computer Networks-I	1						
CS2200	Algorithm-I	1						
CS2210	Theory of Computation-I	1						
EE2120	Computer Organization	1						
EE2310	Information Science	1						
EE2020	Linear Electronics	1						

Course No	Course Name	Credits	A full Semester					
			Time Segments when it runs					
			1/6	2/6	3/6	4/6	5/6	6/6
PH1031	Physics Lab	2						
PH2017	Relativity	1						
PH2117	Photonics	1						
MA2110	Probability	1						
ID1041	Engineering Drawing	2						
BM1030	Bio-engineering	1						
Laxxxx	Liberal and Creative Arts Electives	2						
		20						
SEM – 4								
EE2140	CMOS Fabrication	1						
EE2210	Power Electronics	1						
EE2130	Advance Analog Electronics	2						
CS2300	Algorithm-II	2						
CS2370	Database Management System Internals	2						
CS2371	Database Management System Internals (Lab)	2						
CS2310	Theory of Computation-II	2						
PH2027	Quantum Physics	1						
PH2127	Astroparticle Physics	1						
PH2041	Physics Lab	2						
Laxxxx	Liberal and Creative Arts Electives	1						
		17						
SEM – 5								
EE2110	Digital systems and Design	1						
EE2511	Basic Electrical Engineering Lab	2						
EE2320	Digital Modulation Technique	1						
EE2010	Device Physics	2						
PH3127	Hydrogenic Atoms	1						
PH3237	Approx methods in Quantum Mechanics	1						
PH3317	Thermal Physics	1						
PH2197	Complex Analysis	1						
PH2177	Linear Vector Spaces	1						
PH2187	Fourier Series and Integral Transforms	1						
PH3227	Nonlinear Dynamics	1						
PH3367	Experimental techniques	1						
PH3117	Wave Formalism of Quantum Mechanics	1						
PH3051	Physics Lab	2						
Laxxxx	Liberal and Creative Arts Electives	2						
XXxxxx	Free elective	2						
		21						
SEM - 6								
PH3288	Analytical Mechanics	2						
PH2287	Special functions and Differential Equation	1						

Course No	Course Name	Credits	A full Semester					
			Time Segments when it runs					
			1/6	2/6	3/6	4/6	5/6	6/6
PH3348	Statistical Physics	2						
PH3338	Photonics and Laser	2						
PH3347	Crystal Structure	1						
PH3337	High Energy Physics	1						
PH3287	Atomic and Molecular Physics	1						
PH3257	Scattering Theory	1						
PH3267	Symmetries in Quantum Mechanics	1						
PH3277	Relativistic Quantum Mechanics	1						
PH2297	Group theory	1						
PH2218	Electrodynamics	2						
PH3061	Physics Lab	2						
LAxxxx	Liberal and Creative Arts Electives	2						
		20						
SEM – 7								
PH4268	Solid State Physics	2						
PH3478	Particle Physics	2						
PH3537	Nuclear Physics	1						
PH3358	Spectroscopy	2						
PH4368	Characterization Techniques	2						
PHxxxx	Core Elective	2						
PH4075	Project	3						
PH4071	Lab	2						
Laxxxx	Liberal and Creative Arts Electives	2						
XXxxxx	Free Electives	2						
		20						
SEM - 8								
PHxxxx	Core-Electives	2						
PHxxxx	Core-Electives	2						
PHxxxx	Core-Electives	2						
XXxxxx	Free Electives	2						
XXxxxx	Free Electives	2						
LAxxxx	Liberal and Creative Arts (Professional Ethics)	2						
		12						

ENGINEERING SCIENCE

Course No	Course Name	Credits	A full Semester					
			Time Segments when it runs					
			1/6	2/6	3/6	4/6	5/6	6/6
SEM – 1								
ID1054	Digital Fabrication	2						
ID1200	Introduction to programming	2						
ID1201	Introduction to programming Lab	1						
ID1035	Independent Project	1						
EE1110	Boolean Algebra	1						
MA1110	Calculus-I	1						
MA1220	Calculus-II	2						
EE2010	Computer Organization	1						
Laxxxx	Liberal and Creative Arts Electives	2						
CY1017	Environmental Chemistry-1	1						
EE2110	Digital Systems and Design	1						
XXxxxx	Free Elective	2						
SEM – 2								
BO1010	Introduction to Life Sciences	1						
Laxxxx	Liberal and Creative Arts Electives	2						
CS1230	Introduction to Data Structures	1						
CS1231	Data Structures Lab	2						
ID1140	Thermodynamics – I	1						
MA1130	Vector Calculus	1						
MA1140	Linear Algebra	1						
MA1150	Differential Equations	1						
PH1027	EM and Maxwells Equation	1						
CY1027	Dynamics of Chemical Systems-I	1						
EE1170	Embeded programming	1						
PH2027	Quantum Physics	1						
BM1050	Brain Machine Interface	1						
XXxxxx	Free Elective	2						
SEM – 3								
EE1010	Electric Circuits	1						
MS1050	Physics of Solids	1						
CY1030	Environmental Chemistry-II	2						
PH1017	Classical Physics	1						
BM1030	Bio-engineering	1						
ID1100	Fluid Mechanics-I	2						
EE2010	Device Physics	2						
PH2117	Photonics	1						
CS2210	Theory of Computation-1	1						
CS2200	Algorithms-1	1						
CS2250	Computer Networks-1	1						
CH2070	Numerical Methods-1	2						

Course No	Course Name	Credits	A full Semester					
			Time Segments when it runs					
			1/6	2/6	3/6	4/6	5/6	6/6
Laxxxx	Liberal and Creative Arts Electives	2						
XXxxxx	Free Elective	2						
SEM - 4								
MA2140	Statistics	1						
MA2130	Complex Variables	1						
CH2140	Numerical Methods-2	2						
ME2070	Introduction to Mathematical Modelling	1.5						
CS2300	Algorithms-II	2						
CS2310	Theory of Computation II	2						
ME1020	Dynamics	2						
BM1040	Neuromuscular Physiology	1						
EE2160	Embedded Programming	1						
EE2140	CMOS Fabrication	1						
EE2220	Control systems	1						
MS1070	Semiconductor Materials	1						
LAxxxx	Liberal and Creative Arts Electives	2						
XXxxxx	Free Elective	2						

MECHANICAL ENGINEERING

Course No	Course Name	Credits	A full Semester					
			Time Segments when it runs					
			1/6	2/6	3/6	4/6	5/6	6/6
SEM – 1								
ID1035	Independent Project	1						
MA1110	Calculus-I	1						
MA1220	Calculus-II	2						
PH1017	Classical Physics	1						
ID1130	Engineering Statics	2						
ID1100	Fluid Mechanics-I	2						
ME1010	Manufacturing Technology	1						
ID1054	Digital Fabrication	2						
ID1041	Engineering Drawing	2						
ID1081	Fabrication Lab-I	2						
Laxxxx	Liberal and Creative Arts Electives	2						
SEM – 2								
MA1130	Vector Calculus	1						
MA1140	Linear Algebra	1						
MA1150	Differential Equations	1						
PH1027	Electro Magnetism and Maxwells Equation	1						
CY1027	Dynamics of Chemical Systems-I	1						
CY1021	Dynamics of Chemical Systems-II	2						
BO1010	Introduction to Life Sciences	1						
ME1020	Dynamics	2						
ID1160	Solid Mechanics–I	2						
ID1140	Thermodynamics–I	1						
ID1091	Fabrication Lab–II	2						
Laxxxx	Liberal and Creative Arts Electives	2						
XXxxxx	Free Electives	1						
SEM – 3								
MA2110	Probability	1						
MA2120	Transforms	1						
PH1031	Physics Lab	2						
CY1017	Environmental Chemistry–I	1						
BM1030	Bio-engineering	1						
ID1200	Introduction to Programming	1						
ID1201	Introduction to Programming (lab)	2						
EE1110	Boolean Algebra	1						
EE1010	Electric Circuits	1						
EE1020	Magnetic Circuits	1						
MS1010	Science and Engineering of Materials	1						
MS2020	Physical Metallurgy	2						
ID1110	Fluid Mechanics-II	1.5						

Course No	Course Name	Credits	A full Semester					
			Time Segments when it runs					
			1/6	2/6	3/6	4/6	5/6	6/6
ID2020	Solid Mechanics-II	2						
Laxxxx	Liberal and Creative Arts Electives	2						
SEM – 4								
MA2130	Complex Variables	1						
MA2140	Statistics	1						
PHxxxx	Physics (elective)	1						
ME2060	IC Engines–I	1						
ME2070	Introduction to Mathematical Modelling	1.5						
ME2040	Instrumentation	1.5						
ME2030	Manufacturing Science–I	2						
ME2220	Kinematics and Dynamics of Machinery	4						
ID1150	Thermodynamics-II	2						
ME2421	Solid Mechanics Lab	1						
ME2431	Fluid Mechanics Lab	1						
Laxxxx	Liberal and Creative Arts Electives	2						
XXxxxx	Free Electives	1						
SEM – 5								
ME3010	Manufacturing Science-II	2						
ME3020	IC Engines-II	3						
ME3130	Design of Machine Elements	4						
ME3110	Heat and Mass transfer	3						
ME3445	Finite Element Methods Lab	1						
ME3455	Computational Fluid Dynamics Lab	1						
EE2511	Basic Electrical Engineering Lab	2						
Laxxxx	Liberal and Creative Arts Electives	2						
XXxxxx	Free Electives (total 3 for 5 and 6 sems)	0-3						
SEM – 6								
ME3030	Modeling and Simulation	3						
ME3040	Mathematical Elements for Geometrical Modeling	1.5						
ME3050	Computer Integrated Manufacturing	1.5						
ME3060	Experimental Testing Techniques	1						
ME3413	Machine Drawing and Solid Modelling	2						
ME3425	Mini-project	3						
ME3465	Manufacturing Lab	1						
ME3475	IC Engines Lab	1						
Mexxxx	Core-Electives	3						
Laxxxx	Liberal and Creative Arts Electives	2						
XXxxxx	Free Electives (total 3 for 5 and 6 sems)	0-3						
SEM – 7								
ME4010	Control Systems	1.5						
ME4325	Elective Project / Core Elective	3						

Course No	Course Name	Credits	A full Semester					
			Time Segments when it runs					
			1/6	2/6	3/6	4/6	5/6	6/6
ME4020	Turbo Machines	3						
ME4030	Operations Research	1						
ME4040	Industrial Engineering	1						
ME4050	Production Planning and Control	1						
ME4435	Dynamics lab	1						
ME4445	Heat Transfer lab	1						
Mexxxx	Core-Electives (total 9 for 7 and 8 sems)	0-3						
SEM - 8								
LAxxxx	Liberal and Creative Arts Electives	2						
XXxxxx	Free Electives (total 4 for 7 and 8 sems)	0-2						
MExxxx	Core-Electives (total 9 for 7 and 8 sems)	6-9						
LAxxxx	Liberal and Creative Arts (Professional Ethics)	2						
XXxxxx	Free Electives (total 4 for 7 and 8 sems)	2-4						

MATERIALS SCIENCE AND METALLURGICAL ENGINEERING

Course No	Course Name	Credits	A full Semester					
			Time Segments when it runs					
			1/6	2/6	3/6	4/6	5/6	6/6
SEM – 1								
MS1010	Science and Engineering of Materials	1						
MS1020	Metallic Materials	1						
MS1030	Materials Characterization-I	1						
MS1040	Materials Synthesis	1						
MS1050	Physics of Solids	1						
ID1035	Independent Project	1						
CY1017	Environmental Chemistry-I	1						
BM1030	Bio-engineering	1						
ID1054	Digital Fabrication	2						
PH1031	Physics Lab	2						
CY1031	Chemistry Lab	2						
xxxx	Liberal Arts + Creative Arts Electives	2						
xxxx	Free elective	1						
SEM – 2								
MS1060	Polymers	1						
MS1070	Semiconductor materials	1						
MS1080	Computational Methods in Materials Science-I	1						
MS1090	Micro-mechanics of solids	1						
PH2027	Quantum Physics	1						
PH1027	Electro Magnetism and Maxwells Equations	1						
MA2140	Statistics	1						
MA1140	Linear Algebra	1						
CY1027	Dynamics of Chemical Systems-I	1						
CY1021	Dynamics of Chemical Systems-II	2						
BO1010	Introduction to Life Science	1						
MS1011	Metallography Lab	1						
MS1021	Materials Synthesis Lab	1						
xxxx	Liberal Arts + Creative Arts Electives	2						
xxxx	Free elective	1						
SEM – 3								
MS2010	Soft Matter Science	1						
MS2020	Physical Metallurgy	2						
MS2040	Advanced Materials Synthesis	2						
EE1010	Electrical Circuits	1						
EE1020	Magnetic Circuits	1						
ID1200	Introduction to Programming	1						
PH1017	Classical Physics	1						
MA1110	Calculus-I	1						
MA1220	Calculus-II	2						
ID1041	Engineering Drawing	2						
ID1081	Fabrication Lab-I (Workshop)	2						

Course No	Course Name	Credits	A full Semester					
			Time Segments when it runs					
			1/6	2/6	3/6	4/6	5/6	6/6
ID1201	Introduction to Programming Lab	2						
xxxx	Liberal Arts + Creative Arts Electives	2						
xxxx	Free elective	1						
SEM – 4								
MS2050	Mechanical Behaviour of Materials	2						
MS2070	Ceramics and Refractories	1						
MS2080	Process Metallurgy	1						
MS2060	Functional and Structural polymers	2						
MS2030	Materials Characterization-II	2						
MS2090	Electronic Materials	1						
MS2100	Rate Phenomena in Process Modeling	1						
ID1160	Solid Mechanics-I	2						
MA1130	Vector Calculus	1						
MA1150	Differential Equations	1						
MS2011	Functional Properties Characterization Lab	2						
MS2021	Mechanical Behaviour Lab	2						
xxxx	Liberal Arts + Creative Arts Electives	2						
xxxx	Free elective	1						
SEM - 5								
MS3010	Magnetic Materials	1						
MS3020	Casting and solidification	2						
MS3030	Non-Ferrous extractive metallurgy	1						
MS3040	Thin Films	2						
MS3050	Iron making	1						
MS3060	Steel making	1						
MS3070	Powder Metallurgy	2						
MS3090	Phase Equilibria	1						
MS3100	Kinetics of Materials	2						
ME1010	Manufacturing Technology	1						
MS3011	Powder Metallurgy Lab	1						
MS3021	Foundry and solidification Lab	1						
xxxx	Liberal Arts + Creative Arts Electives	2						
xxxx	Core Elective	2						
xxxx	Free Elective	1						
SEM - 6								
MS3110	Transport phenomena	2						
MS3120	Phase Transformations	2						
MS3080	Computational Methods in Materials Science-II	2						
MS3130	Non-destructive testing	1						
MS3140	Technical communication	1						
MS3150	Corrosion	1						
ME2030	Manufacturing Science-I	2						

Course No	Course Name	Credits	A full Semester					
			Time Segments when it runs					
			1/6	2/6	3/6	4/6	5/6	6/6
MS3015	Mini project	3						
MS3011	Heat Treatment Lab	2						
xxxx	Liberal Arts + Creative Arts Electives	2						
xxxx	Core Elective	2						
xxxx	Free Elective	1						
SEM – 7								
MS4010	Defects in functional materials	1						
MS4020	Research methodology	1						
MS4030	Materials Selection and design	1						
MS4040	Recycling of Materials	1						
MS4011	Metal Forming Lab	1						
xxxx	Liberal Arts + Creative Arts Electives	2						
xxxx	Core Elective	3						
xxxx	Free Elective	2						
SEM - 8								
MS4050	Fracture and Fatigue	2						
MS4060	Thermo-mechanical Processing	2						
MS4016	Seminar	1						
xxxx	Liberal Arts + Creative Arts Electives	2						
xxxx	Core Elective	2						
xxxx	Free Elective	3						
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IIT Hyderabad

2 Year
M.Tech. Programs

DEPARTMENT OF CHEMICAL ENGINEERING

Course No	Course Name	Credits
	SEM - 1	
CH5010	Numerical Methods-I	2
CH5020	Numerical Methods-II	1
CH5030	Chemical Engineering Thermodynamics-I	2
CH5040	Chemical Engineering Thermodynamics-II	1
CH5050	Non-Isothermal Reactors	2
CH5060	Heterogeneous Reaction Engineering	1
CH5091	Simulation Lab-I	2
	Electives	4
	Total Credits	**15**
	SEM - 2	
CH5070	Transport Phenomenon-I	1.5
CH5080	Transport Phenomenon-II	1.5
CH5116	Seminar	1
	Electives	8
CH5015	Thesis (Stage 1)	3
	Total Credits	**15**
	SEM - 3	
CH5101	Simulation Lab-II	2
CH5025	Thesis (Stage 2)	12
	Total Credits	**14**
	SEM - 4	
CH5035	Thesis (Stage 3)	15
	Total Credits	**15**

DEPARTMENT OF MECHANICAL ENGINEERING (IDM)

Course No	Course Name	Credits	A full Semester					
			Time Segments when it runs					
			1/6	2/6	3/6	4/6	5/6	6/6
SEM – 1								
ME5010	Mathematical Methods for Engineers	3						
ME5020	Elasticity and Plasticity	1.5						
ME5030	Fluid Mechanics and Heat Transfer	1.5						
ME5040	Computational Fluid Dynamics (CFD) Tools (Theory + Lab)	1.5						
ME5130	Finite Element Methods: Theory	3						
ME5421	Finite Element Methods: Lab	1						
ME5050	Material Science and Material Selection	1.5						
ME5060	Manufacturing Processes	2						
ME5070	Design for Manufacturability and Assembly	1						
ME5080	Scaling Laws and Multi-scale Manufacture	1						
SEM – 2								
ME5090	Mathematical Elements for Geometrical Modeling	1.5						
ME5100	Computer Integrated Manufacturing	1.5						
ME5140	Process Control and Optimization	1.5						
ME5150	Computational Intelligence	1.5						
ME5160 ME5170 ME5180	Choose one from: (1) Material Removal Processes (2) Welding and Joining (3) Metal Forming Processes	3						
ME5431	Integrated Design and Manufacturing Lab	2						
Mexxxx	Core Electives	3						
XXxxxx	Free Electives	1						
SEM – 3								
ME6106	Seminar Course	1						
ME6005	Thesis (Stage1)	14						
SEM - 4								
ME6505	Thesis (Stage2)	15						

IIT Hyderabad

COURSE DESCRIPTIONS

DEPARTMENT OF BIOMEDICAL ENGINEERING

BM1030: Bio-engineering — Credit: 1

This course gives a rigorous overview of the field of bioengineering. It covers basic concepts of Biomedical Engineering and connects the biological systems to the common theme of engineering analysis. The topics addressed in this course include 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, force, displacement, blood pressure and temperature sensors, will be addressed in this course.

Reading Material:

- Medical Instrumentation Application and Design, John Webster Ed. John Wiley and Sons 2009.
- Operational Amplifiers and linear ICs,R. A. Gayakwad, Phi Learning, 2009.

BM1040: Neuromuscular Physiology — Credit: 1

Basic understanding of human physiology with respect to peripheral neurons and muscles; cellular and physiological systems with respect to peripheral neurons, neuromuscular junction and skeletal muscles; action potential and electrical conductivity of peripheral neurons; smooth muscles and their differences to skeletal muscles.

Reading materials:

- Kim E. Barrett, Heddwen Brooks, Scott Boitano, Susan M. Barman. Ganong's Review of Medical Physiology. 24th edition. McGraw-Hill Education.
- John E. Hall. Guyton and Hall Textbook of Medical Physiology. 12th Edition, 2010. Saunders.

BM1050: Brain Machine Interfaces — Credit: 1

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.

Reading Material (Pdfs will be provided to students):

- Brain-Machine Interface Engineering. J. C. Sanchez and J. C. Principe. Morgan and Claypool Publishers, 2007.
- MATLAB for Neuroscientists. An introduction to scientific computing in MATLAB. P. Wallisch, M. Lusignan, M. Benayoun, T. I. Baker, A. S. Dickey, N. G. Hatsopoulos. Academic Press, 2009.

DEPARTMENT OF BIOTECHNOLOGY

BO1010: Introduction to Life Sciences — Credit: 1

Relevance of Biological Principles to Engineering undergraduates, Water and its special properties of relevance to life - Building blocks of life: Bio-molecules and their structure-function aspects - Cell structure and organelles, cell membrane, cellular transport and signaling, Cell metabolism and its regulation; Cell energetics: harvesting chemical and solar energy - Classical and Molecular genetics, Introduction to the molecular basis of human diseases: genetic diseases, non-infectious diseases (Cancer) and infectious diseases, Origin of life and Evolution.

DEPARTMENT OF CHEMICAL ENGINEERING

CH1010: Material and Energy Balances — Credits: 2

Basic concepts: units and dimension, material properties, process variables and stoichiometry; Techniques for problem solving; Steady state material and energy balances for processes involving no reaction/reaction; species and elemental balances, Recycle, bypass and purge calculations; Multiple units, multiphase system; De-Coupled and coupled mass and energy balances; Analysis of degree of freedom in a steady state process; Unsteady state material and energy balances.

Reading Material:

- D.M. Himmelblau and J.B. Riggs, "Basic Principles and Calculations in Chemical Engineering" 7th edition. Prentice Hall of India, New Delhi, 2003.
- G.V. Rekliatis, "Introduction to Material and Energy Balances" Wiley, New York, 1983.

CH1060: Solids Handling and Comminution — Credit: 1

Principles and unit operations involved in the granular solid systems. Characterization of particulate solids, solids handling, mixing of solids, Comminution theory and devices in terms of industrial crushers, tumbling mills and ultrafine grinders.

Reading Material:

- Warren L. McCabe, Julian Smith, Peter Harriott, Unit Operations of Chemical Engineering. McGraw-Hill Education (ISE Editions); 7th edition, 2005.
- Wills B.A. Napier-Munn, T.J., Mineral Processing Technology, Seventh Edition, Elsevier Publishers, 2006

CH1080: Engineering Materials — Credit: 1

Synthesis and properties of Lubricants, Adhesives, Paints, Explosives and other liquids.

Reading Material:

- Jain, P.C., Jain, M. Engineering Chemistry, 2012, 15th Ed., Dhanpat Rai Publishing Company.
- Hymer D. Gesser, Applied Chemistry: A textbook for Engineers and Technologists, Kluwer Academic Publisher, 2002

CH1100: Sustainable Energy — Credit: 1

World energy resources and consumption; conventional energy sources; solar energy; Wind Energy; Tidal and Geothermal Energy; Biomass energy resources: conversion methods, combustion, gasification, and pyrolysis; Biogas production, fuel cells.

Reading Material:

- Renewable Energy Technologies, by Jean-Claude Sabonnadière, Wiley 2009
- Fundamentals of renewable energy process by Aldo V. da Rosa, Academic Press, 2009

CH1120: Chemical Technology — Credit: 1

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.

Reading Material:

- C.E. Dryden, Dryden's outlines of Chemical Technology for the 21st century, (Edited and revised by M.G. Rao and M. Sitting) 2006.
- James H. Gary, Glenn E. Handwerk, Mark J. Kaiser, Petroleum Refining: Technology and Economics. CRC Press, 5th edition, 2007.

CH1140: Interfacial Chemistry — Credit: 1

Intermolecular Forces (Van der Walls, Acid-base and electrostatic etc.), Shape of the interface, Wettability and Adhesion.

Reading Material:

- Arthur Adamson, Physical Chemistry of Surfaces, 6th Ed., Wiley Publications, 1997
- Paul C. Hiemenz, Principles of colloid and surface chemistry, 3rd Ed., Marcel Dekker, NY, 1997

CH2010: Principles of Mass Transfer — Credit: 1

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

Reading Material:

- R. E. Treybal, Mass-Transfer Operations, 3rd Ed, McGraw Hill, 1981.

CH2050: Mechanical Separation [Pre-req: CH1060] — Credits: 2

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.

Reading Material:

- Warren L. McCabe, Julian Smith, Peter Harriott, Unit Operations of Chemical Engineering. McGraw-Hill Education (ISE Editions); 7th edition, 2005.
- Wills B.A. Napier-Munn, T.J., Mineral Processing Technology, Seventh Edition, Elsevier Publishers, 2006

CH2070: Numerical Methods-I — Credits: 2

Linear Algebraic Equations - Eigen Values and Eigenvectors of matrices – Solution of Nonlinear algebraic equations - Function evaluation.

Reading Material:

- Numerical Methods for Engineers by Prof. S. K. Gupta, 5-th Ed., New Age International, 2010.

CH2020: Gas Liquid Operations [Pre-req: CH2010] — Credits: 2

Theory of Interphase Mass Transfer, Absorption Operations and Equipment used, Overview of Distillation

Reading Material:

- B. K. Dutta, Principles of Mass Transfer and Separation Processes, Prentice Hall of India, 2007.
- R. E. Treybal, Mass-Transfer Operations, 3rd Ed, McGraw Hill, 1981.

CH2040: Chemical Reaction Engineering — Credits: 2

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, PK/PD basics (Pharmacokinetics, pharmacodynamics).

Reading Material:

- Chemical Reaction Engineering, Octave Levenspeil, Fourth edition, 2011.
- Elements of Chemical reaction Engineering, H. Scott. Fogler, Fourth Edition, 2006

CH2060: Non-Ideal Reactors [Pre-req: CH2040] Credit: 1

Residence time distribution (RTD), RTD in ideal reactors, Reactor modeling using RTD, Segregation model, Maximum mixedness model, RTD and multiple reactions, Models of non-ideal reactor, Tank-in-series model, Dispersion model, Modeling real reactors with combination of ideal reactors, determination of model parameters.

Reading Material:

- Chemical Reaction Engineering, Octave Levenspeil, Fourth edition, 2011.
- Elements of Chemical reaction Engineering, H. Scott. Fogler, Fourth Edition, 2006

CH2080: Transportation and Mixing of Fluids [Pre-req: ID2030] Credit: 1

Transportation of liquid fluids and flow measurement, pipe and tube, fitting and valves, pumps, fans, blowers and compressors, measuring devices such as full-bore meters and insertion meters. Agitation and mixing of fluid in terms of agitation vessels, blending and mixing of fluids and suspension, dispersion operations, agitator selection and scale up.

Reading Material:

- Centrifugal Pump Design, John Tuzson, John Wiley and Sons publisher, 1st edition, 2000.
- Geankoplis C. J., Transport Processes and Separation Process Principles, Prentice Hall; 4th edition, 2003

CH2100: Modes of Heat Transfer Credits: 2

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.

Reading Material:

- Heat Transfer, J. P Holman and S. Bhattacharyya, Tata McGraw-Hill 2011
- Unit operation of chemical engineering, 7th Edition, W.L. McCabe, J.C. Smith, P. Harriot, McGraw-Hill 2005

CH2120: Heat Transfer Equipment [Pre-req: CH2100] Credit: 1

Boiling and condensation; Heat exchangers: classification; logarithmic mean temperature difference (LMTD); Overall and individual heat transfer coefficients; Heat transfer coefficient in shell and tube exchangers; LMTD correction; effectiveness and number of transfer units (NTU); Evaporators: single effect/multiple effect; methods of feeding; enthalpy balance.

Reading Material:

- Unit operation of chemical engineering, 7th Edition, W.L. McCabe, J.C. Smith, P. Harriot, McGraw-Hill 2005
- Process heat transfer, D.Q. Kern, Tata McGraw-Hill 1997

CH2140: Numerical Methods-II Credits: 2

Ordinary Differential Equations Initial Value Problems - Ordinary Differential Equations Boundary Value Problems - Solution of relevant Chemical Engineering problems using these methods.

Reading Material:

- Numerical Methods for Engineers by Prof. S. K. Gupta, 5-th Ed., New Age International, 2010.

CH2160: Petrochemical Industry Credit: 1

Preparation of process flow diagrams, instrumentation diagrams, and process symbols. Manufacturing of petrochemical feed stocks: olefins and aromatics; chemicals from benzene-toluene-xylenes (BTX) and olefins (ethylene, propylene, and butylene).

Reading Material:

- C.E. Dryden, Dryden's outlines of Chemical Technology for the 21st century, (Edited and revised by M.G. Rao and M. Sitting) 2006.
- James H. Gary, Glenn E. Handwerk, Mark J. Kaiser, Petroleum Refining: Technology and Economics. CRC Press, 5th edition, 2007.

CH3010: Liquid-Liquid and Solid-Liquid Operations [Pre-req: CH2010] Credits: 2

Extraction and Equipment used for it, Drying and Equipment used for it, Examples of other S-L operations.

Reading Material:

- B. K. Dutta, Principles of Mass Transfer and Separation Processes, Prentice Hall of India, 2007.
- R. E. Treybal, Mass-Transfer Operations, 3rd Ed, McGraw Hill, 1981.

CH3030: Chemical Engineering Thermodynamics-I Credits: 2

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.

Reading Material:

- Chemical, Biochemical and Engineering Thermodynamics by Sandler, 4-th Ed., John Wiley, 2006
- Molecular Thermodynamics of Fluid Phase Equilibria by Prausnitz, 3-rd Ed., Prentice Hall, 1999.

CH3050: Non-Isothermal Reactors [Pre-req: CH2040] Credit: 1

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.

Reading Material:

- H. Scot Fogler, Elements of Chemical Reaction Engineering, Prentice Hall, Second edition, 1986.
- J.M. Smith, Chemical Engineering Kinetics, Mcgraw Hill, Third Edition, 1981.

CH3070: Transport phenomena-I Credits: 2

Vector and tensor algebra and calculus. Momentum transport – Viscosity, stress tensor, mechanisms of momentum transport; shell momentum balances, boundary conditions; governing equations: equations of continuity, 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.

Reading Material:

- Bird, R.B., Stewart, W.E. and Lightfoot E.N., Transport Phenomena, Revised 2nd edition, John Wiley and Sons, 2006. ISBN: 9780470115398.
- Deen W. M., Analysis of transport phenomena, Oxford University Press, 1998. ISBN: 978-0195084948.

CH3090: Heat Transfer Equipment Design [Pre-req: CH2120] Credit: 1

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

Reading Material:

- Chemical Engineering Design, Fourth edition, volume 6; Author: Coulson and Richardson's Chemical Engineering Series; Publishers: Butterworth-Hinemann,an imprint of Elsevier; Year: 2005
- Process Heat Transfer; Author: D Q Kern; Publishers: McGraw-Hill, Year: 1997.

CH3110: Control Design and Analysis — Credits: 2

Modelling, Linearization, Stability, LTI systems, Inverse Response, Feedback, Pole Placement, Loop interactions, Frequency Analysis, Bode stability criterion, Gain and Phase Margins, Nyquist plot, Cauchy's Principle, Nyquist stability, Sensitivity Functions, Internal Stability, Robust Stability Theorem, Fundamental Limitations, Effect of NMP/ LHP zeros on control Design, Sensitivity Bounds,IMP, Feed-forward, Cascade control.

Reading Material:

- Control System Design by Graham Goodwin et. al. Prentice Hall, 2001
- Introduction to Process Control by George Stephanopolous, PHI Learning Private Limited, 2012

CH3130: Optimization Techniques-I — Credits: 2

Formulation of optimization problem - Unconstrained optimization - Analytical and numerical techniques for single / multi-variable unconstrained optimization - Evolutionary Algorithms - Solving real life problems using Numerical Optimization.

Reading Material:

- S. S. Rao, Engineering Optimization: Theory and Practice, New Age Intl. Publishers, New Delhi, 3rd Enlarged Ed., 2011.
- T. F. Edger, D. M. Himmelblau, L S Lasdon, Optimization of Chemical Processes, McGrawHill, 2nd Edition, 2001.

CH3020: Mass Transfer Equipment Design [Pre-req: CH2010, CH2020, CH3010] Credits: 2

Gas-liquid operation: Absorption and stripping in multistage operation, side stream addition/withdrawal, countercurrent, co-current and cross current process; Design of tray tower and packed tower, Equilibrium curve, operating line, number of ideal stages, Efficiency, Kremser equation, HETP, height and number of transfer unit, types of packing, pressure drop, flooding/loading.

Reading Material:

- Mass transfer operations, Robert E Treybal
- Principles of mass transfer operations, Binay K. Dutta, Sixth Ediion, 2007

CH3040: Heterogeneous Reaction engineering [Pre-req: CH2040] — Credit: 1

Adsorption kinetics, kinetics of catalytic reaction, diffusion and reaction in porous catalysts, design of fixed bed reactors, shrinking core model, catalyst deactivation, design for deactivating catalysts, fluid bed reactors, design of fluid bed reactors, applications, overview, and design of slurry and trickle bed reactors.

Reading Material:

- H. Scot Fogler, Elements of Chemical Reaction Engineering, Prentice Hall, Second edition, 1986.
- J.M. Smith, Chemical Engineering Kinetics, Mcgraw Hill, Third Edition, 1981.

CH3060: Transport Phenomena-II [Pre-req: CH3070] — Credits: 2

Dimensional analysis of the equations of change; Momentum Transport - Time-dependent, and 2D flows: creeping, inviscid, potential flows; boundary layer theory; Turbulent flows. Energy Transport - Forced, free convection: Boussinesq equation; temperature distributions with more than one independent variable: unsteady conduction, steady conduction in laminar flow. Mass Transport - concentration distributions with more than one independent variable.

Reading Material:

- Bird, R.B., Stewart, W.E. and Lightfoot E.N., Transport Phenomena, Revised 2nd edition, John Wiley and Sons, 2006. ISBN: 9780470115398.
- Deen W. M., Analysis of transport phenomena, Oxford University Press, 1998. ISBN: 978-0195084948.

CH3080: Polymer Engineering — Credit: 1

Introduction to Polymeric Materials, Structure and Characterization of Polymers, Properties of Polymers, Functionalization of Polymers, Recent development in Polymer Materials.

Reading Material:

- Polymer Engineering Science and Viscoelasticity: An Introduction by Hal F. Brinson, L. Catherine Brinson, Springer Publications.
- Young, R.J., Introduction to Polymers, Chapman and Hall, 1981

CH3100: Optimization Techniques-II — Credits: 1

Constrained optimization - Analytical and numerical techniques for single / multi-variable constrained optimization - Integer programming - Solving real life problems using Numerical Optimization.

Reading Material:

- S. S. Rao, Engineering Optimization: Theory and Practice, New Age Intl. Publishers, New Delhi, 3rd Enlarged Ed., 2011.
- T. F. Edger, D. M. Himmelblau, L S Lasdon, Optimization of Chemical Processes, McGrawHill, 2nd Edition, 2001.

CH3120: Cell Dynamics — Credit: 1

Cell signaling network: Reaction-diffusion systems, mathematical modeling of biological system in time and space, simulation of non-linear network dynamics, parametric sensitivity; System properties: ultrasensitivity/amplification/ bistability/oscillation/crosstalk/robustness; Cell data analysis: Fourier/wavelet analysis, Correlation; Probability distributions, Clustering, Model fitting and parameter estimation.

Reading Material:

- Control theory and systems biology, Pablo A Iglesias and Brian P Ingalls, 2010, The MIT Press, Cambridge, Masachusettes, London, England.
- An Introduction to Systems Biology: Design Principles of Biological Circuits, Uri Alon, 2006, Clapman and Hall/CRC, Mathematical and computational biology series.

CH3140: Bio-molecular Kinetics — Credit: 1

Bio-molecular interactions, enzyme kinetics, immobilization of biomolecules, bioenergetics and bio-reaction networks, Molecular and cellular concepts on DNA, RNA, plasmid Isolation and estimation, role of restriction digestion and ligation, production of acids, enzymes, antibiotics and metabolites in view of biochemical aspects, Cellular engineering.

Reading Material:

- Comprehensive enzyme kinetics; V. Leskovac Kluwer; Publishers: Academic/Plenum Publishers; Year-2003.
- Molecular cell biology; Lodisch.H; Publishers: W.H.Freeman and Co; Year-2004.

CH3160: Bio-refinery — Credit: 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.

Reading Material:

- James H. Gary, Glenn E. Handwerk, Mark J. Kaiser, Petroleum Refining: Technology and Economics. CRC Press, 5th edition, 2007.
- Birgit Kamm, Patrick R. Gruber, Michael Kamm, Bio-refineries - industrial processes and products: status quo and future directions. Volume 1&2, Wiley-VCH, 2006.

CH3180: Introduction to Nanotechnology — Credit: 1

Physical aspects of Nanosciences, Synthesis of Nanomaterials, Characterization of Nanomaterials, Nanofabrication methods.

Reading Material:

- Nanostructures and Nanomaterials: Synthesis, Properties and Applications by Guozhong Cao, Imperial College Press 2004.
- Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience, Edward L. Wolf, 2nd Edition, Wiley 2006.

CH3300: Distillation [Pre-req: CH2010, CH2020] — Credits: 2

Flash distillation: Binary VLE, Multicomponent VLE - Sequential and Simultaneous procedures. Column Distillation: (Binary), Equipment, Flow regimes, External and Internal Balances, CMO, McCabe-Thiele Method and Limiting operating conditions, Transient model, Linearization and simulation, Ponchon Savarit Method. Column Distillation (Multicomponent): Bubble point calculations, Internal Balances, convergence, Energy Balance, Batch distillation.

Reading Material:

- Chemical Engineering Design, Fourth edition, volume 6; Author: Coulson and Richardsons, Chemical Engineering Series; Publishers: Butterworth-Hinemann,an imprint of Elsevier; Year: 2005.
- Separation Process Engineering, Philip C. Wankat, Second Edition

CH4010: Chemical Engineering Thermodynamics–II [Pre-req: CH3030] — Credit: 1

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.

Reading Material:

- Thermodynamics and Introduction to Thermostatistics by H.B.Callen, 2-nd Ed., John Wiley, 1985.
- Chemical, Biochemical and Engineering Thermodynamics by Sandler, 4-th Ed., John Wiley, 2006

CH4030: Process Plant Design — Credits: 2

Process Synthesis, Materials and Energy Balance, Computer Aided Design, Flow-sheet Development, Aspects of Instrumentation-Control-Safety-Storage-Materials, Economic Analysis, Case Studies.

Reading Material:

- Plant Design and Economics for Chemical Engineers by Max Peters, Klaus Timmerhaus, Ronald West, McGraw-Hill Education, 2003 (or Tata McGraw, 2011, Indian Edition)
- Chemical Engineering Design, 2nd Edition by Towler and Sinnott, Buttlerworth-Heinemann, 2012

CH4050: Bio-Mechanics — Credit: 1

Overview of Dynamics of bio-mechanics, mechanical motion analysis, and human performance forces acting upon and within a biological structure. Function of bones, muscles, tendons, ligaments, nerves, and cartilages.

Reading Material:

- Basic Biomechanics; Author: Hall, Susan; Publishers: McGraw Hill; Year: 2012
- Skeletal function and form: mechanobiology of skeletal development, aging, and regeneration; Author: DR Carterand GS Beaupré; Publishers: Cambridge University Press; Year: 2001.

CH4020: Air Pollution — Credit: 1

Sources, classification and effects; Global warming and ozone depletion due to air pollution; Automotive pollution, catalytic converters and particulate filters; Control methods and equipment.

Reading Material:

- Handbook of heterogeneous catalysis, Vol-1, Gerhard Ertl, Helmuth Knözinger, Ferdi Schüth, Jens Weitkamp (Editors), Wiley-VCH Verlag GmbH& Co. KGaA, Weinheim, Germany
- Air pollution, M.N. Rao and H.V. N.Rao, Tata McGraw-Hill, 1989

CH4040: Process Intensification — Credit: 1

Process intensification: a paradigm shift in design; 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 reactors and adsorbers; Micro devices: mixers, separators, heat exchangers, reactors for desk-top manufacture in Pharmaceutical/ fine chemicals.

Reading Material:

- Process Intensification: Engineering for efficiency, sustainability and flexibility, Reay D., Ranshaw C., Harvey A., Butterworth Heinemann, 2008.
- Microreactor technology and process intensification, Jamelyn Holladay, Yong Wang, Eds., American Chemical Society Symposium Series, 2005.

CH4060: Safety and Hazards — Credit: 1

Definitions and Aspects of Industrial Safety, General Protocol and Scope Identification, Chemical Hazards classification, Handling and storage of hazardous chemicals, HAZOP, fault tree analysis, Case Studies.

Reading Material:

- Industrial Hazards and Plant Safety, Sanjoy Banerjee, CRC Press, 2002.
- Guidelines for Process Hazards Analysis, Hazards Identification, and Risk Analysis, Nigel Hyatt, Dyadem Press, 2003

CH5010: Numerical Methods-I — Credits: 2

Linear Algebraic Equations - Eigen Values and Eigenvectors of matrices – Solution of Nonlinear algebraic equations - Function evaluation.

Reference

- Numerical Methods for Engineers by Prof. S. K. Gupta, 5-th Ed., New Age International, 2010.

CH5020: Numerical Methods-II — Credit: 1

Ordinary Differential Equations Initial Value Problems - Ordinary Differential Equations Boundary Value Problems - Solution of relevant Chemical Engineering problems using these methods.

Reference

- Numerical Methods for Engineers by Prof. S. K. Gupta, 5-th Ed., New Age International, 2010.

CH5030: Chemical Engineering Thermodynamics-I — Credits: 2

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.

References:

- Chemical, Biochemical and Engineering Thermodynamics by Sandler, 4-th Ed., John Wiley, 2006
- Molecular Thermodynamics of Fluid Phase Equilibria by Prausnitz, 3-rd Ed., Prentice Hall, 1999.

CH5040: Chemical Engineering Thermodynamics-II — Credit: 1

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.

References

- Thermodynamics and Introduction to Thermostatistics by H.B.Callen, 2-nd Ed., John Wiley, 1985.
- Chemical, Biochemical and Engineering Thermodynamics by Sandler, 4-th Ed., John Wiley, 2006

CH5050: Non-Isothermal Reactors — Credits: 2

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.

References

- H. Scot Fogler, Elements of Chemical Reaction Engineering, Prentice Hall, Second edition, 1986.
- J.M. Smith, Chemical Engineering Kinetics, Mcgraw Hill, Third Edition, 1981.

CH5060: Heterogeneous Reaction Engineering — Credit: 1

Adsorption kinetics, kinetics of catalytic reaction, diffusion and reaction in porous catalysts, design of fixed bed reactors, shrinking core model, catalyst deactivation, design for deactivating catalysts, fluid bed reactors, design of fluid bed reactors, applications, overview, and design of slurry and trickle bed reactors.

References

- H. Scot Fogler, Elements of Chemical Reaction Engineering, Prentice Hall, Second edition, 1986.
- J.M. Smith, Chemical Engineering Kinetics, Mcgraw Hill, Third Edition, 1981.

CH5070: Transport Phenomena-I — Credits: 1.5

Vector and tensor algebra and calculus. Momentum transport – Viscosity, stress tensor, mechanisms of momentum transport; shell momentum balances, boundary conditions; governing equations: equations of continuity, 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.

References

- Bird, R.B., Stewart, W.E. and Lightfoot E.N., Transport Phenomena, Revised 2nd edition, John Wiley and Sons, 2006. ISBN: 9780470115398.
- Deen W. M., Analysis of transport phenomena, Oxford University Press, 1998. ISBN: 978-0195084948.

CH5080: Transport Phenomena-II — Credits: 1.5

Dimensional analysis of the equations of change; Momentum Transport - Time-dependent, and 2D flows: creeping, inviscid, potential flows; boundary layer theory; Turbulent flows. Energy Transport - Forced, free convection: Boussinesq equation; temperature distributions with more than one independent variable: unsteady conduction, steady conduction in laminar flow. Mass Transport - concentration distributions with more than one independent variable.

References

- Bird, R.B., Stewart, W.E. and Lightfoot E.N., Transport Phenomena, Revised 2nd edition, John Wiley and Sons, 2006. ISBN: 9780470115398.
- Deen W. M., Analysis of transport phenomena, Oxford University Press, 1998. ISBN: 978-0195084948.

CH5091: Simulation Lab-I — Credits: 2

ASPEN: Overview and applications of Aspen Plus; Setting up a problem in Aspen Plus, Property analysis and estimation: analysis of properties of pure components and binary mixtures, analysis of thermodynamic diagrams of binary mixtures, estimation of properties of new compounds; Simulation and design of reactors, distillation column; heat exchangers; simulation of simple and complex flow sheets; performing sensitivity analysis; Performing optimization; creating user defined models; analysis of pipeline hydraulics using Aspen Hysys Pipesys.

CH5101: Simulation Lab-II — Credits: 2

CFD simulations involved in various chemical engineering processes: fluid flow, heat transfer, and multi-phase systems. Case studies for simulating and analyzing flow system using ANSYS Fluent software: Fluid flow modeling in a hydrocyclone separator –VOF model demonstration by simulating air purging in a vessel - Conjugate heat transfer over a computer chip board – Simulating unsteady heat transfer in steel ladle flow - 2D unsteady flow of power - law fluids over a cylinder - Modeling the Effect of Sedimentation Concentration in a Secondary Clarifier using a UDF - 2D simulation of circulating fluidized bed using E - E model - Demonstration of DPM model for dilute particle flow in gas cyclone.

CH5116: Seminar — Credit: 1

Students are required to choose a researchtopic to deliver a seminar. Research topic may beoffered by faculty and/or may be chosen by students and get it approved by the instructor. The main objective is to develop skills in literature search, communication and presentations.

CH5120: Surface Science and Catalysis — Credits: 2

Type: Elective

Thermodynamics and kinetics of surfaces; crystal and electronic structures of clean surfaces (metals and semiconductors); adsorption and desorption; surface kinetics and dynamics including diffusion; dynamics of growth and etching; surface reaction models; a survey of modern surface analytical techniques.

References

- P.W. Atkins and Julio de Paula, Physical Chemistry, 9th Edition, Oxford University Press, 2009
- D.A. McQuarrie and J.D. Simon, Physical Chemistry - A Molecular Approach, University Science Books, 1997
- A.W. Adamson, A.P. Gast, Physical Chemistry of Surfaces, 6th Edition, Wiley 1997.
- Kurt W. Kolasinski, Surface Science: Foundations of Catalysis and Nanoscience, Wiley 2002.
- B. Viswanthan, S. Sivasanker and A.V. Ranmaswamy, Catalysis: Principles and Applications, by, Narosa 2002.
- G.A. Somorjai, Y. Li, Introduction to Surface Chemistry and Catalysis, 2nd Ed. John Wiley and Sons Inc, New Jersey, 2010.

CH5130: Chemical Reactor Modeling — Credits: 2

Type: Elective

Thermodynamic principles: calculation of specific heat, enthalpy, and entropy based on NASA polynomials; Calculation Gibbs free energy; Calculation of thermodynamic properties of gas mixture; Calculation of transport properties: Viscosity and Diffusion coefficients. Rate expressions from elementary kinetic mechanisms for gas phase reactions; Mean-field approximation and surface kinetics; Equilibrium constant for gas-phase and surface reactions; Energy balance and species continuity equations for various reactor configurations; Solution of governing equations using numerical methods.

References

- Chemically reacting flow, R. J. Kee, M. E. Coltrin, P. Glarborg, Wiley Interscience, 2003
- Combustion, J. Wartanz, U. Mass, R. W. Dibble, Springer, 4th Edition, 2006

CH5140: Advanced Topics in Thermodynamics — Credits: 2

Type: Elective

Overview of Modern Thermodynamics with recent advancements; In search of most reliable postulates; Introduction of non-equilibrium through stability and fluctuations; Local equilibrium and Onsagar reciprocal relations; Applications of non-equilibrium thermodynamics with examples; Interactive learning of related and recent research topics

References

- Thermodynamics and Introduction to Thermostatistics by H.B.Callen, 2-nd Ed., John Wiley, 1985.
- Modern Thermodynamics by Kondepudi and Prigogine, John Wiley, 1998.

CH5150: Optimization Techniques-I — Credits: 2

Type: Elective

Formulation of optimization problem - Unconstrained optimization - Analytical and numerical techniques for single / multi-variable unconstrained optimization - Evolutionary Algorithms - Solving real life problems using Numerical Optimization

References

1. S. S. Rao, Engineering Optimization: Theory and Practice, New Age Intl. Publishers, New Delhi, 3rd Enlarged Ed., 2011.
2. T. F. Edger, D. M. Himmelblau, L S Lasdon, Optimization of Chemical Processes, McGrawHill, 2nd Edition, 2001.

CH5160: Optimization Techniques-II — Credit: 1

Type: Elective

Constrained optimization – Analytical and numerical techniques for single / multi-variable constrained optimization – Integer programming – Solving real life problems using Numerical Optimization

References

- S. S. Rao, Engineering Optimization: Theory and Practice, New Age Intl. Publishers, New Delhi, 3rd Enlarged Ed., 2011.
- T. F. Edger, D. M. Himmelblau, L S Lasdon, Optimization of Chemical Processes, McGrawHill, 2nd Edition, 2001.

CH5170: Viscous Fluid Flow-I — Credit: 1

Type: Elective

Fundamental equations of fluid flow: Navier-Stokes, continuity and energy equations, Boundary conditions for viscous flow, Dimensionless parameters, Introduction to boundary layer

Reference

- Viscous fluid flow by Frank M. White.
- Boundary-layer theory by H. Schlichting and K. Gersten
- Hydrodynamics by H. Lamb

CH5180: Viscous Fluid Flow-II — Credits: 2

Type: Elective

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, source-sink pairs, Rankine half body, lifting and non-lifting flow over a cylinder, 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: RANS equations.

Reference

- Viscous fluid flow by Frank M. White.
- Boundary-layer theory by H. Schlichting and K. Gersten
- Hydrodynamics by H. Lamb

CH5190: Introduction to Mineral Processing — Credit: 1

Type: Elective

This course briefs the knowledge of mineral processing in terms of Mineral processing introduction; Process overview, metals vs minerals; Metallurgical accounting, control and simulations of simple and complex circuits; Mineral liberation

References

- Wills B.A. Napier-Munn, T.J., Mineral Processing Technology, Seventh Edition, Elsevier Publishers, 2006.
- J.W.Leonard III, Coal Preparation, 5th Edition, SME Inc., 1992
- Mineral Comminution Circuits, Their Operation and Optimisation Edited by Tim Napier-Munn, JKMRC Monograph,1996.

CH5200: Advanced Mineral Processing — Credits: 2

Type: Elective

This course is a full details and comprehensive knowledge of advance aspects of mineral processing, designing and selection of processing equipment and machinery. The following topics are explained in this course: Comminution theory; Models of comminution process; Grinding mills, designs and modeling; Screening and classification; Dense medium separation; Gravity separations; Froth flotation

References:

- Wills B.A. Napier-Munn, T.J., Mineral Processing Technology, Seventh Edition, Elsevier Publishers, 2006.
- J.W.Leonard III, Coal Preparation, 5th Edition, SME Inc., 1992
- Mineral Comminution Circuits,Their Operation and Optimisation Edited by Tim Napier-Munn, JKMRC Monograph,1996.

CH5210: Introduction to Solid-Liquid Separations — Credit: 1

Type: Elective

Characterization of particles in liquids; Particle sizing techniques; Particle drag and settling rates; Rheology of slurries; Efficiency indices of separation of particles; Coagulation and flocculation

References

- Ladislav Svarovsky, Solid-Liquid separations, Fourth Edition, Butterworth-Heinemann, 2000
- Warren L. McCabe, Julian Smith, Peter Harriott, Unit Operations of Chemical Engineering. McGraw-Hill Education (ISE Editions); 7th edition, 2005.
- Wills B.A. Napier-Munn, T.J., Mineral Processing Technology, Seventh Edition, Elsevier Publishers, 2006.
- Wallace Woon and Fong Leung, Industrial Centrifugation Technology, McGraw-Hill Education (ISE Editions); 1998.

CH5220: Advanced Solid-Liquid Separations — Credits: 2

Type: Elective

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

References

- Ladislav Svarovsky, Solid-Liquid separations, Fourth Edition, Butterworth-Heinemann, 2000
- Warren L. McCabe, Julian Smith, Peter Harriott, Unit Operations of Chemical Engineering. McGraw-Hill Education (ISE Editions); 7th edition, 2005.
- Wills B.A. Napier-Munn, T.J., Mineral Processing Technology, Seventh Edition, Elsevier Publishers, 2006.
- Wallace Woon and Fong Leung, Industrial Centrifugation Technology, McGraw-Hill Education (ISE Editions); 1998.

CH5230: Single-phase Non-Newtonian Fluids — Credits: 2

Type: Elective

Introduction: Definitions, Newtonian vs Non-Newtonian (NN) Fluids, NN behavior examples, NN Fluids in Engineering Practice

Structure and Rheology: Examples in NN fluids

Basics: Balance equations, Axioms in Constitutive Modeling, NN model examples

Single phase fluids: Generalized Newtonian, Differential (Grade 2), Rate-type (Maxwell, Oldroyd-B), and Integral models (Lodge-Rubberlike, K-BKZ)

References

- C. Truesdell, K. R. Rajagopal, An Introduction to the Mechanics of Fluids, Birkhauser Boston, 2000.
- R. B. Bird, R. C. Armstrong, O. Hassager, Dynamics of Polymeric Liquids, vol1: Fluid Mechanics, 2nd Ed, John Wiley and Sons, 1987.

CH5240: Multi-phase Non-Newtonian Fluids — Credit: 1

Type: Elective

Multi-phase fluids: Gas-Liquid flows, Solid-Liquid flows

Particulate systems: Spheres in Shear-thinning and Viscoplastic fluids, Fluid drops in Non-Newtonian fluids

Rheometry: Material parameters, Rheometers

References

- R. P. Chhabra, Bubbles, Drops, and Particles in Non-Newtonian Fluids, 2nd Ed, Taylor and Francis (CRC), 2007

CH5250: Cardiovascular Mechanics – Theory — Credits: 2

Type: Elective

Motivation: Mechanics and human health, cardiovascular health

Definitions: Molecules, Cells, Tissues, Organs, Anatomy, Physiology

Cardiovascular System: structures and their functions

Vasculature: anatomy and physiology, regulation of BP and tissue perfusion

Heart: anatomy and physiology, systole-diastole, pressure-flow

Blood: constituents and functions, tests

Continuum Mechanics: Kinematics, Balance equations, Constitutive models, Formulation and Solution of problems

References

- E.N. Marieb, Human Anatomy and Physiology, 6th Edition, Pearson Education, New Delhi, 2006.
- J.D. Humphrey, Cardiovascular Solid Mechanics: cells, tissues, and organs, Springer-Verlag, NY, 2002.

CH5260: Cardiovascular Mechanics – Problems Credit: 1

Type: Elective

Problems involving mechanics of vasculature/heart, rheology of blood Simulation of blood flow in arteries and the dynamics of heart valves

References

- J.D. Humphrey, Cardiovascular Solid Mechanics: cells, tissues, and organs, Springer-Verlag, NY, 2002.
- K.B. Chandran, S.E. Ritgers, A.P. Yoganathan, Biofluid Mechanics (the human circulation), 2nd Edition, CRC Press, Boca Raton, 2012.

CH5270: Biochemical signals and systems–I Credit: 1

Type: Elective

Introduction to biochemical system: molecules to pathway, pathway to network, network to physiology, genetic, metabolic and signaling network. Components of biochemical system: Reaction network, covalent modification, Hill kinetics, co-operativity, cascade effect, transportation of ions, polymerization-depolymerization cycles, mutual inhibition. Quantification of biochemical signals: Live cell/tissue and fixed tissue imaging (confocal, two-photon, transmission electron microscopy), genetic sensors, optogenetics, biological data analysis.

References

- Control theory and systems biology, Pablo A Iglesias and Brian P Ingalls, Johns Hopkins University and University of Waterloo, 2010, The MIT Press, Cambridge, Masachusettes, London, England.
- Systems biology: Simulation of dynamic network states, Bernhard O. Palsson, University of California San Diego, 2011, Cambridge University press.
- An Introduction to Systems Biology: Design Principles of Biological Circuits, Uri Alon, Weizmann Institute of Science, 2006, Clapman and Hall/CRC, Mathematical and computational biology series.

CH5280: Biochemical Signals and Systems-II Credits: 2

Type: Elective

Mathematical physiology: Examples from Neuron differentiation, Immune cell migration, Cell contractility, Cell cycle and growth, Apoptosis

Identification of network motif: Control structures, Positive and negative feedback, Feedforward control, Integral feedback controls in biology.

Oscillatory systems in biology: Modeling and analysis of oscillatory system, Phase plane analysis, time frequency analysis.

Current challenges in biological system: Modeling of live cell data from heart cell, neuron cell and immune cells, cancer cell, data driven modeling.

(Projects will be given on practical challenges and actual live cell data obtained from medical schools (USA)/hospitals/ IIT Hyderabad)

References

- Control theory and systems biology, Pablo A Iglesias and Brian P Ingalls, Johns Hopkins University and University of Waterloo, 2010, The MIT Press, Cambridge, Masachusettes, London, England.
- Systems biology: Simulation of dynamic network states, Bernhard O. Palsson, University of California San Diego, 2011, Cambridge University press.
- An Introduction to Systems Biology: Design Principles of Biological Circuits, Uri Alon, Weizmann Institute of Science, 2006, Clapman and Hall/CRC, Mathematical and computational biology series.

CH5290: Basics of Nanosciences and Nanotechnology — Credits: 2

Type: Elective (Open for Final Year Undergraduates/any PG students)

Total 19 Lectures (1.5 hours each)

A. Overview of Nanoworld: History, Basic concepts (Feynman, Moore's Law), Special Properties of Materials at Nano scale, Emergence of Nanotechnology: Schrodinger equation, electron confinement, density of states (0D, 1D, 2D, 3D)

B. Synthesis of Nanomaterials (Physical and Chemical methods) Carbon Nanomaterials (CNT, CNF, Graphene, Fullerene)

C. Nanofabrication Top-down methods Bottom-up Methods Self-assembly and self-organization

D. Characterization of Nanomaterials Lab visits (Demonstration of characterization methods) e.g. SEM, TEM, SAXS, XRD, AFM, Lithography, PECVD etc.

E. Applications of Nanotechnology

F. Challenges in the field (Technical, Ethical, Health Concerns etc.)

References:

- Nanostructured Materials and Nanotechnology, Concise edition, Editor: Hari Singh Nalwa, Academic Press 2002.
- Nanostructures and Nanomaterials: Synthesis, Properties and Applications by Guozhong Cao, Imperial College Press 2004.
- Nanotubes and Nanowires: RSC Nanoscience and Nanotechnology Series, C.N.R.Rao and A. Govindaraj, The Royal Society of Chemistry 2005.
- Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience, Edward L. Wolf, 2nd Edition, Wiley 2006.
- Nano: The Essentials, Understanding Nanoscience and Nanotechnology, T. Pradeep, TMH Publications, 2007.

Suggested Readings

Journals

1. ACS Nano	2. Nanoletters	3. Journal of Nanoscience and Nanotechnology
4. Nanotechnology	5. Langmuir	6. Small
7. Soft Matter	8. Nanoscale	9. Advanced Materials

CH5300: Biomimicking and Bioinspiration — Credit: 1

Type: Free Elective (For all UG and PG students)

Total 10 Lectures (1.5 hours each)

A. Introduction to Biomimicking and Bioinspiration

B. Innovations inspired by Nature: Case Studies

C. Designing Biomimetics

Term Project

References

- Biomimicry: Innovation Inspired by Nature by Janine Benyus, Harper Collins Publisher Inc., NY
- Biomimetics by Bharat Bhushan. Springer Publication

Suggested Reading

- Research Articles from different journals

CH5310: Mathematical Methods – Differential Equations Credits: 2

Type: Elective

First, Second, and Higher Order Linear ODEs, Homogeneous and Nonhomogeneous ODEs, Systems of ODEs, Series Solutions of ODEs, Laplace Transforms;Fourier Analysis; Partial Differential Equations

Reference

- Kreyszig, Erwin, Advanced Engineering Mathematics, 10th edition, John Wiley and Sons, 2011. ISBN: 978-0470458365

CH5320: Mathematical Methods – Linear Algebra and Vector Calculus Credit: 1

Type: Elective

Matrices, Vectors, Vector Space, Tensors, Determinants; Matrix Eigenvalue Problems; Vector and Tensor Differential Calculus; Vector Integral Calculus.

Reference

- Kreyszig, Erwin, Advanced Engineering Mathematics, 10th edition, John Wiley and Sons, 2011. ISBN: 978-0470458365

CH5330: Mathematical Methods – Complex Analysis Credit: 1

Type: Elective

Complex Numbers and Functions; Complex Differentiation; Complex Integration; Conformal Mapping; Complex Analysis and Potential Theory

Reference

- Kreyszig, Erwin, Advanced Engineering Mathematics, 10th edition, John Wiley and Sons, 2011. ISBN: 978-0470458365

DEPARTMENT OF CHEMISTRY

CY1017: Environmental Chemistry-I — Credit: 1

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.

Textbooks:

- Principles of Environmental Chemistry, Second Edition, James E. Girard, Jones and Barlett Publishers, 2011.
- Chemistry of the Environment, R.A. Bailey, H.M. Clark, J.P. Ferris, S. Krause, R.L. Strong, Academic Press, Elsevier, 2005.

CY1027: Dynamics of Chemical Systems-I — Credit: 1

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.

References

- Linden's Handbook of Batteries, Thomas Reddy (Ed.), McGraw-Hill Professional; 4th Edition (December 2010).
- Kinetics and Mechanisms of Chemical Transformations, J Rajaram, J C Kuriacose, Macmillan Publishers India Limited, 2000.
- Quantum Chemistry - Donald A. McQuarrie, John D Simon, Viva Books Pvt. Ltd.
- Physical Chemistry - P.W. Atkins, 8th Edition, Oxford University Press.

CY1021: Dynamics of Chemical Systems-II — Credits: 2

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.

References

1. Linden's Handbook of Batteries, Thomas Reddy (Ed.), McGraw-Hill Professional; 4th Edition (December 2010).
2. Kinetics and Mechanisms of Chemical Transformations, J Rajaram, J C Kuriacose, Macmillan Publishers India Limited, 2000.
3. Quantum Chemistry - Donald A. McQuarrie, John D Simon, Viva Books Pvt. Ltd.
4. Physical Chemistry - P.W. Atkins, 8th Edition, Oxford University Press.

CY1011: Environmental Chemistry-II — Credits: 2

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, SO_2, 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 (CO_2 sequestering, Nuclear energy), a project on environment related topic.

Textbooks:

- Principles of Environmental Chemistry, Second Edition, James E. Girard, Jones and Barlett Publishers, 2011.
- Chemistry of the Environment, R.A. Bailey, H.M. Clark, J.P. Ferris, S. Krause, R.L. Strong, Academic Press, Elsevier, 2005.

CY1031: Chemistry Lab — Credits: 2

A laboratory course designed to illustrate the fundamental principles of organic, inorganic and physical chemistry. Experiments include synthesis of aspirin, estimation of phenol, qualitative analysis of an organic compound, estimation of copper in brass, determination of hardness of water, reaction kinetics, formation constant of KI3, acid strength of a citrus fruit and estimation of sodium oxide in cement.

DEPARTMENT OF CIVIL ENGINEERING

ID1130: Engineering Statics — Credits: 2

Idealization in mechanics; Equilibrium of a particle and a rigid body; Types of Structures and Supports; Free - Body Diagram; Truss analysis using method of joints and sections; Statically determinate system; Force analysis in frames and machines; Internal forces; Relationship between applied load, shear force, and bending moment; Parallel-axis theorem; Polar moment of area; Radius of gyration.

Reading Material:

- F. Beer and Jr. E. R. Johnston, "Vector Mechanics for Engineers: Statics and Dynamics", 2006, McGraw Hill.
- R.C. Hibbeler and A. Gupta, "Engineering Mechanics: Statics and Dynamics", 2010, 12th Edition, Pearson Prentice Hall, New Jersey, USA.

CE2100: Introduction to Structural Analysis — Credits: 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.

Reading Material:

- Russell C. Hibbeler, "Structural Analysis" (8th Edition), Prentice Hall; 8 edition (March 7, 2011)
- Devdas Menon, "Structural Analysis", Alpha Science International, Limited, 2008

CE2101: Structural mechanics Lab — Credits: 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 — Credits: 2

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.

Reading Material:

- Russell C. Hibbeler, "Structural Analysis" (8th Edition), Prentice Hall; 8 edition (March 7, 2011)
- DevdasMenon, Advanced Structural Analysis, Alpha Science International, Limited, 2009

CE2020: Construction Materials — Credits: 1.5

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 ; Asphalt, Bitumen And Tar: Tests for Bitumen, Tar, bituminous materials, steel and aluminium, polymers and plastics, Composites and wood.

Reading Material:

- Charles G. Salmon, John E. Johnson, Faris A. Malhas, "Steel Structures: Design and Behavior (5th Edition) Prentice Hall; (October 26, 2008)
- Mamlouk, Michael S; Zaniewski, John P, "Materials for civil and construction engineers", Prentice Hall, c2011.

CE2021: Construction Materials Lab — Credits: 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.

Reading Material:

- M.S. Mamlouk and J.P. Zaniewski, *Materials for Civil and Construction Engineers*, Pearson, Prentice Hall, Second edition, 2006.
- A.M., Neville and J.J. Brooks, *Concrete Technology*, Pearson Education, Fourth Indian reprint, 2004.

CE2030: Concrete Technology — Credits: 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.

Reading Material:

- A.M. Neville, *Concrete Technology*, Pearson, Education India, 2008.
- S. Mindess, J.F. Young and D. Darwin, Concrete, Pearson Prentice Hall, 2nd Edition, 2002.

CE2500: Engineering Hydrology — Credits: 2

Measurement, analysis, and interpretation of various components of hydrologic system (precipitation, infiltration, runoff, evapotranspiration); Rainfall - Runoff correlations; Hydrograph analysis; Groundwater hydrology and well hydraulics.

Reading Material:

- Engineering Hydrology by K. Subramanya (2nd Edition), Tata Mc-Graw Hill Publications
- Groundwater Hydrology by David Keith Todd (2nd Edition), John Wiley and Sons Inc.

CE3010: Fundamentals of GIS and Remote Sensing — Credits: 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.

Reading Material:

- Introduction to Remote Sensing by James B Campbell (5th Edition) Guilford Press
- Fundamentals of Geographic Information Systems by Michael N Demers (3rd Edition) Wiley Publishers

CE3011: GIS Lab — Credit: 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

Reading Material:

- ERDAS Imagine and ArcGIS Desktop user guides
- Mastering ArcGIS by Maribeth Price (3rd Edition)

CE3102: Introduction to Reinforced Concrete — Credits: 1.5

Mechanical properties of reinforced concrete materials including shrinkage, and creep; Load displacement behaviour under pure compression and pure tension; Basic Bending Theory; Moment-curvature and load-deflection relationships; Shear Behaviour of RC Members; Torsional Behaviour of RC Members.

Reading Material:

- S. Unnikrishna Pillai and Devdas Menon, Reinforced Concrete Design, 3rd Edition, 2009, Tata Mcgraw Hill
- J.G. MacGregor, Reinforced Concrete - Mechanics and Design, 4th Edition, Prentice Hall, 2007
- R. Park and T. Paulay, Reinforced Concrete Structures, John Wiley and Sons, 1975

CE3020: Surveying — Credits: 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.

Reading Material:

- Walter S. Whyte, R. E. Paul,Basic Surveying, Butterworth-Heinemann, 1997
- B. C. Punmia, Arun Kr. Jain, Ashok Kr. Jain, Surveying (Volume - 1), Laxmi Publications 2005

CE3112: Introduction to Structural Steel Design — Credits: 1.5

Mechanical Properties of Steel; Effect of Corrosion; Fire and Fatigue; Limit State Design - Analysis procedures and Design Philosophy; - Types of Beam Buckling Failures, Beam Columns.

Reading Material:

- Charles G. Salmon, John E. Johnson, Faris A. Malhas, “Steel Structures: Design and Behavior (5th Edition) Prentice Hall; (October 26, 2008)
- N. Subramaniam, “Design of Steel Structures”, 2008, Oxford University Press.

CE3122: Reinforced Concrete Design — Credits: 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.

Reading Material:

- S. Unnikrishna Pillai and Devdas Menon, Reinforced Concrete Design, 3rd Edition, 2009, Tata Mcgraw Hill
- J.G. MacGregor, Reinforced Concrete - Mechanics and Design, 4th Edition, Prentice Hall, 2007

CE3132: Design of Steel Structures — Credits: 1.5

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; Beams, Connections - Bolted Connections Welding and Welded Connections -Bolt Group, Weld Group; Beam and Column Splices

Reading Material:

- N. Subramaniam, “Design of Steel Structures”, 2008, Oxford University Press.
- Charles G. Salmon, John E. Johnson, Faris A. Malhas, “Steel Structures: Design and Behavior (5th Edition) Prentice Hall; (October 26, 2008)

CE3300: Geotechnical Engineering-I — Credits: 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.

Reading Material:

- Principles of Geotechnical Engineering by B. M. Das, Seventh Edition, Cengage Learning, 2010.
- An Introduction to Geotechnical Engineering by R. D. Holtz, W. D. Kovacs and T. C. Sheahan, Second Edition, Pearson, Prentice Hall, 2011.

CE3310: Geotechnical Engineering-II — Credits: 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.

Reading Material:

- Principles of Geotechnical Engineering by B. M. Das, Seventh Edition, Cengage Learning, 2010.
- An Introduction to Geotechnical Engineering by R. D. Holtz, W. D. Kovacs and T. C. Sheahan, Second Edition, Pearson, Prentice Hall, 2011.

CE3301: Geotechnical Engineering Lab — Credits: 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.

Reading Material:

- Soil Mechanics Laboratory Manual by B. M. Das, Sixth Edition, Oxford University Press, 2002.

CE3312: Introduction to Foundation Engineering — Credit: 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.

Reading Material:

- Principles of Foundation Engineering by B. M. Das, Seventh Edition, Cengage Learning, 2010.
- Foundation Analysis and Design by J. E. Bowles, Fifth Edition, McGraw Hill, 1997

CE3322: Design of Foundations — Credits: 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.

Reading Material:

- Principles of Foundation Engineering by B. M. Das, Seventh Edition, Cengage Learning, 2010.
- Foundation Analysis and Design by J. E. Bowles, Fifth Edition, McGraw Hill, 1997

CE3500: Introduction to Hydraulic Engineering — Credits: 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.

Reading Material:

- Hydraulic Engineering by John A. Roberson , John J. Cassidy , and M. Hanif Chaudhry, 2nd Edition, John Wiley and Sons Inc.
- Hydraulics of pipelines by J Paul Tullis, John Wiley and Sons Inc.

CE3501: Hydraulic Engineering Lab — Credit: 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.

Reading Material:

- Laboratory Manual will be supplied in the class

CE3510: Open Channel Hydraulics — Credits: 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.

Reading Material:

- Flow in Open Channels by K. Subramanya (3rd Edition), Tata Mc-Graw Hill Publications
- Flow through open Channels by Rajesh Srivastava, Oxford University Press

CE3511: Environmental Engineering Lab — Credits: 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.

Reading Material:

- Standard Methods for the Examination of Water and Wastewater by American Public Health Association, AWWA (American Water Works Association), Water Environment Federation, E.W. Rice, R.B. Baird, A.D. Eaton, L. S. Clesceri, 22nd Edition, 2012
- Peavy, H.S, Rowe, D.R., and G. Tchobanoglous, (1985) Environmental Engineering, McGraw Hill Inc., N.York

CE3512: Introduction to Environmental Engineering — Credit: 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.

Reading Material:

- William W. Nazaroff and Lisa Alvarez-Cohen, (2000), Environmental Engineering Science, John Wiley and Sons
- Mackenzie Davis and David Cornwell, (2012), Introduction to Environmental Engineering, McGraw-Hill

CE3522: Water and Wastewater Engineering — Credits: 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.

Reading Material:

- Metcalf and Eddy, Inc. (2003), Waste water Engineering Treatment and Reuse, McGraw Hill Inc., New Delhi
- Tom Reynolds and Paul Richards, (1996), Unit Operations and Processes in Environmental Engineering, Cengage Learning

CE3800: Transportation Engineering-I — Credits: 3

Properties of traffic elements; Highway design, typical road cross-section, horizontal and vertical curves; Traffic flow, characterization, uninterrupted traffic flows and models, signalized intersections; Design of traffic facilities, Freeways and expressways; Transit system operation and planning; Trip generation and distribution models; Highway economics.

Reading Material:

- Partha Chakroborty, Animesh Das, Principles of Transportation Engineering, PHI Learning Pvt. Ltd., 01-Jan-2003

CE3810: Transportation Engineering-II Credits: 3

Pavement materials and characterization; Pavement analysis, composition, bituminous or concrete; Wheel load, wheel configuration, tyre pressure, pavement temperature; Pavement design: AASHTO design method, Indian Road Congress method; Airport pavement; Highway construction; Highway maintenance.

Reading Material:

- Partha Chakroborty, Animesh Das, Principles of Transportation Engineering, PHI Learning Pvt. Ltd., 01-Jan-2003

CE4502: Water Resources Engineering Credits: 2

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

Reading Material:

- Irrigation and Water Resources Engineering by G L Asawa, New age International Publishers
- Water Resource Engineering by Larry W Mays (2nd Edition), John Wiley and Sons Inc.

CE4900: Construction Management Credits: 3

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.

Reading Material:

- Calin M. Popescu, ChotchaiCharoenngam, Project Planning, Scheduling and Control in Construction: An Encyclopaedia of terms and Applications, Wiley, New York, 1995.
- Chitkara, K.K. Construction Project Management: Planning, Scheduling and Control, McGraw-Hill Publishing Company, New Delhi, 1998.

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

ID1200: Introduction to Computer Programming — Credit: 1

Problem solving and algorithms. Introduction to C language covering input and output operations, decision control structure, loop control structure, functions and pointers, arrays, strings, structures and unions, file operations.

References:

- The C Programming Language, B.W. Kernighan, Dennis M.Ritchie, PHI/Pearson Education.
- C How to Program-Deitel and Deitel.
- Computer science, A structured programming approach using C, B.A. Forouzan and R.F. Gilberg, Third edition, Thomson.

CS1210: Proof Techniques — Credit: 1

Concept of mathematical proof, proof by contradiction, mathematical induction, constructive proofs, sets, relations.

References:

- Lecture Notes on Mathematics for Computer Science - Lehman, Leighton and Meyer
- Discrete Mathematics and its applications - Kenneth H. Rosen

CS1220: Automata Theory — Credit: 1

Alphabets, languages, finite state machines - deterministic and non-deterministic finite automata.

References:

- Hopcroft, Motwani and Ullman: Introduction to automata theory, languages and computation (eds 1 and 2); Addison Wesley
- Michael Sipser: Introduction to the theory of computation.

CS1230/CS1231: Introduction to Data Structures with Lab — Credits: 1+2

Abstract data types, Big-Oh notation, Time and Space complexity, Basic data types – Stacks, Queues, Trees.

References:

- Introduction to algorithms - Cormen and Leiserson and Rivest and Stein, 2nd/3rd Ed.
- Data structures and algorithms in C++/Java - Adam Drozdek
- Data Structures and algorithms - Aho, Hopcroft, Ullman

CS1240: Software Engineering-I — Credit: 1

Introduction to Software Engineering: Importance, challenges, approaches, Software Processes.

References:

- Software Engineering: A practitioner's approach, 7th ed., Roger Pressman, McGraw Hill
- An Integrated Approach to Software Engineering, Pankaj Jalote, Narosa

CS1250: Combinatorics — Credit: 1

Basic counting principles, inclusion-exclusion, binomial/multinomial coefficients, bijections, double counting, pigeon-hole principle, recurrence relations.

References:

1. Lecture Notes on Mathematics for Computer Science - Lehman, Leighton and Meyer
2. Discrete Mathematics and its applications - Kenneth H. Rosen
3. A path to combinatorics for undergraduates - T. Andreescu

CS1260: Graph Theory — Credit: 1

Degree, isomorphism, diameter, connectivity, trees, matchings, colorings, planarity.

References:

- Introduction to graph theory (2nd edition) by Douglas West
- Graph theory (3rd edition) by Renhard Diestel
- Algorithm Design by Kleinberg and Tardos

CS1270/CS1271: Introduction to Database Management Systems (with Lab) — Credits: 1+1

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

References:

- Database Systems Concepts, A. Silberschatz, H. Korth and S. Sudarshan, McGraw Hill, 6th edition, ISBN 0-07-352332-1
- An Introduction to Database Systems, R. Ramakrishnan and J. Gehrke, 3rd edition
- Fundamentals of Database Systems, R. Elmasri and S. B. Navathe, Addison Wesley, 6th edition

CS1280: Introduction to Operating Systems — Credit: 1

History of OSs, Concurrency vs parallelism, Process management: process states, process vs thread, scheduling algorithms, system calls, IPC, Race conditions, Mutex locks; Main memory: Paging system, File system.

References:

- Operating System Concepts, 9th edition by Silberschatz, Galvin and Gagne (John Wiley)

CS2210: Theory of Computation-I — Credit: 1

Prerequisites: Automata Theory Context Free Grammars, Context Free Languages, Parse trees, Push Down Automata, Pumping lemma for CFLs and applications, CYK algorithm.

References:

- Hopcroft, Motwani and Ullman: Introduction to automata theory, languages and computation (eds 1 and 2); Addison Wesley
- Michael Sipser: Introduction to the theory of computation.

CS2310: Theory of Computation-II — Credits: 2

Prerequisites: Theory of Computation I, Turing machines, Variants, Undecidability theory, Reductions, theory of NP completeness, introduction to time and space complexity

References:

- Hopcroft, Motwani and Ullman: Introduction to automata theory, languages and computation (eds 1 and 2); Addison Wesley
- Michael Sipser: Introduction to the theory of computation.

CS2230/CS2231: Data Structures with Lab — Credits: 2 + 2

Prerequisites: Introduction to Data Structures and Lab More data types. Dictionaries. Binary search trees, Balanced search trees, Hash tables; Heaps, Priority queues, Graphs

References:

- Introduction to algorithms - Cormen and Leiserson and Rivest and Stein, 2nd/3rd Ed.
- Data structures and algorithms in C++/Java - Adam Drozdek
- Data Structures and algorithms - Aho, Hopcroft, Ullman

CS2330: Logic — Credit: 1

Introduction to propositional and first order logic.

References:

Logic in Computer Science, Michael Huth and Mark Ryan, Cambridge University Press, Second Edition

CS2250: Computer Networks-I — Credit: 1

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.

References:

Computer Networking: A Top-Down Approach by James F. Kurose and Keith W. Ross, 6th Edition, 2012, Pearson.

CS2350: Computer Networks-II — Credits: 2

Prerequisites: Computer Networks-I, Network congestion, TCP vs UDP, IPv4 vs IPv6, Routing algorithms, Routing in Internet, ARQ protocols, Local Area Networks (Ethernet, Wi-Fi), Multimedia Networking, and Network Security.

References:

- Computer Networking: A Top-Down Approach by James F. Kurose and Keith W. Ross, 6th Edition, 2012, Pearson.
- Computer Networks: A Systems Approach by Larry L. Peterson and Bruce Davie, 4th Edition, 2007, Morgan Kaufmann

CS2351: Computer Networks Lab — Credits: 2

Prerequisites: Computer Networks I and enrolment to Computer Networks II, Client-Server Design using Socket programming in C/C++, Implementation of multi-threaded Web Sever/Web Proxy with Caching/Filtering features, Sliding Window protocol implementation, performance study of various TCP variants, Wireshark assignments on DNS, HTTP, DHCP, SMTP, TCP, UDP, IP, Ethernet, Wi-Fi, ARP, etc. Hands-on with Cisco routers.

References:

- Computer Networking: A Top-Down Approach by James F. Kurose and Keith W. Ross, 6th Edition, 2012, Pearson.
- UNIX Network Programming, Volume I: The Sockets Networking API by W. Richard Stevens, Bill Fenner, Andrew M. Rudoff, 3rd Edition, 2003, Addison-Wesley
- TCP/IP Illustrated Vol. 1 Protocols by W. Richard Stevens and G. Gabrani, 2001, Addison-Wesley

CS2370/CS2371: Database Management System Internals (with Lab) — Credits: 2

Prerequisites: Introduction to Database Management Systems, Introduction to Database Management Systems Lab, 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.

References:

- Database Systems Concepts, A. Silberschatz, H. Korth and S. Sudarshan, McGraw Hill, 6th edition, ISBN 0-07-352332-1
- An Introduction to Database Systems, R. Ramakrishnan and J. Gehrke, 3rd edition
- Fundamentals of Database Systems, R. Elmasri and S. B. Navathe, Addison Wesley, 6th edition

CS2280: Operating Systems — Credits: 2

Prerequisites: Introduction to Operating Systems, Process synchronization: Semaphores, Monitors, Deadlocks, Virtual memory: demand paging and page replacement algorithms, File system implementation, Disk management, and I/O management; Case studies on Windows/Linux OSs.

References:

- Operating System Concepts, 9th edition by Silberschatz, Galvin and Gagne (John Wiley)
- Modern Operating Systems by Andrew S. Tanenbaum and H. Bos, 4rd Edition, Prentice Hall, Inc, 2014.

CS2281: Operating Systems Lab — Credits: 2

Prerequisites Introduction to Operating Systems and Enrolment to Operating Systems Course 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.

References:

- Operating System Concepts, 9th edition by Silberschatz, Galvin and Gagne (John Wiley)
- Operating Systems: Design and Implementation by Andrew S. Tanenbaum and Albert S.Woodhull, 3rd Edition, Prentice Hall, Inc.
- Online Resources: http://www.minix3.org/, https://moodle.iith.ac.in/

CS2200: Algorithms-I — Credit: 1

Prerequisites: Introduction to Data Structures and Lab Algorithmic Design Paradigms, Divide and Conquer, Analysis for Divide and Conquer, Sorting, Greedy Algorithms.

References:

- Introduction to algorithms - Cormen and Leiserson and Rivest and Stein, 2nd/3rd Ed.
- Data Structures and Algorithms - Aho, Hopcroft, Ullman.
- Algorithms - Dasgupta, Papadimitriou, Vazirani.

CS2300: Algorithms-II — Credits: 2

Prerequisites: Introduction to Data Structures and Lab, Algorithms-I, Greedy Algorithms, Sorting Lower bounds, Dynamic Programming, Graph Algorithms (DFS, BFS, Topological Sort, Single Source Shortest Path, Spanning Trees, All Pair Shortest Path, Matching, Max Flow), FFT.

References:

- Introduction to algorithms - Cormen and Leiserson and Rivest and Stein, 2nd/3rd Ed.
- Algorithms - Dasgupta, Papadimitriou, Vazirani.
- Algorithm Design - Kleinberg, Tardos.

CS3303: Software Technologies — Credits: 2

Prerequisites: Introduction to Programming, Introduction to Programming Lab Latest technologies like Java Script, JSP, Python, Android, Perl, etc to design software artifacts.

CS3320/CS3321: Compilers-I (with lab) Credits: 1+1

Prerequisites: Formal Languages and Automata Theory, Data Structures and Algorithms, Introduction to Programming 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.

References:

- Alfred V. Aho, Ravi Sethi, Jeffrey D. Ullman: Compilers: Principles, Techniques, and Tools. Addison-Wesley 1986.
- Helmut Seidl, Reinhard Wilhelm, Sebastian Hack: Compiler Design, Springer 2012.

CS3420/CS3421: Compilers-II (with lab) Credits: 2+1

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

References:

- Alfred V. Aho, Monica S. Lam, Ravi Sethi, Jeffrey D. Ullman, Compilers: Principles, Techniques, and Tools, Addison-Wesley, 2007
- Steven S. Muchnick: Advanced Compiler Design and Implementation. Morgan Kaufmann 1997.

CS3340: Principles of Programming Languages-I Credits: 1

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

References:

Michael L. Scott, Programming Language Pragmatics, 3rd Edition, Morgan Kaufmann, 2009.

CS3440: Principles of Programming Languages-II Credits: 2

Prerequisites: Principles of Programming Languages-I or Compilers-I, Functional programming, Object Oriented programming, Logic programming, Lambda calculus, Concurrency, Scripting languages, Programming language semantics.

References:

- Michael L. Scott, Programming Language Pragmatics, 3rd Edition, Morgan Kaufmann Publishers, 2009.
- Programming Languages: Concepts and Constructs, 2nd Edition, Addison-Wesley, 1996.
- Benjamin C. Pierce, Types and Programming Languages, MIT Press, 2002.

CS3360: Distributed Computing-I Credit: 1

Prerequisites: Operating Systems, Introduction to distributed computing models; clock synchronization; Message Ordering and Group Communication; Introduction to Termination Detection; Introduction to Distributed Mutual Exclusion Algorithms; Introduction to Deadlock Detection

References:

- A.D. Kshemkalyani, M. Singhal, Distributed Computing: Principles, Algorithms, and Systems, Cambridge University Press, 2011.
- Gerard Tel. Introduction to Distributed Algorithms
- Nancy A. Lynch. Distributed Algorithms

CS4405: Mini Project-II Credits: 2

Independent project supervised by a faculty.

CS3460: Distributed Computing-II — Credits: 2

Prerequisites: Operating Systems, Distributed Computing - 1, 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.

References:

- A.D. Kshemkalyani, M. Singhal, Distributed Computing: Principles, Algorithms, and Systems, Cambridge University Press, 2011.
- Gerard Tel. Introduction to Distributed Algorithms
- Hagit Attiya, Jennifer Welch. Distributed Computing: Fundamentals, Simulations, and Advanced Topics

CS3480: Linear Optimization-I — Credit: 1

Linear algebra, Simplex algorithm, applications.

References:

- LINEAR ALGEBRA: A GEOMETRIC APPROACH, Kumaresan

CS3405: Mini Project-I — Credits: 2

Independent project supervised by a faculty.

CS4440/CS4441: Software Engineering-II (with Lab) — Credits: 1+2

Prerequisites: Software Engineering-I, Requirements Engineering, Software Architecture, Planning, Design, Coding, Testing, Software Project Management, Advanced topics like Formal Methods in Software Engineering

References:

- Software Engineering: A practitioner's approach, 7th ed., Roger Pressman, McGraw Hill
- ˜An Integrated Approach to Software Engineering, Pankaj Jalote, Narosa

CS4480: Linear Optimization-II — Credits: 2

Prerequisites: Linear Optimization-I, Implementation details of simplex algorithm, Primal dual theory, KKT Conditions, Introduction to approximation algorithms

References:

- Lecture notes of Prof. Sundar Vishwanathan
- http://www.cse.iitb.ac.in/~sundar/cs435/

B.Tech Elective Courses / M.Tech courses:

In a given semester only a subset of these elective courses will be offered. List of courses available in a given semester will be made available to the students at the time of registration.

CS3330: Hands-on with NS-3 — Credits: 2

Prerequisites: Computer Networks II, NS-3 architecture, Object model, Tracing, Logging, Flowmonitor, helpers, scenario creation, mobility, traffic sources, discussion on built-in libraries like Wireless, LTE, advanced features like DCE, adding new protocols into NS-3 etc.

References:

- http://www.nsnam.org/

CS3380: Operating Systems Internals — Credits: 2

Prerequisites: Operating Systems, Internal workings of Operating Systems using Linux/Minix as an example; programming projects involving modifications to an operating system kernel on VMs; building the OS kernel, system call interface, process management, kernel services, I/O system, internal workings of the file system, device drivers, and the kernel support of IPC and memory management.

References:

- Unix Internals: The New Frontiers, by Uresh Vahalia (Prentice Hall)
- Advanced Programming in the UNIX Environment (2nd Edition), by Richard Stevens and Stephen Rago (Addison-Wesley)

CS3390: Introduction to Wireless Networks — Credit: 1

Prerequisites: Computer Networks II, Fundamentals of Wireless Communication, Wired vs Wireless Networks, Overview of Wireless LANs, Cellular Systems, Mobile Ad hoc Networks, Wireless Mesh Networks, Bluetooth, Zigbee, etc.

References:

- Mobile Communications by Jochen Schiller, 2nd edition, 2003, Addison-Wesley
- Ad hoc Wireless Networks: Architectures and Protocols by C. Siva Ram Murthy and B. S. Manoj, Prentice Hall, 2004.

CS3470: Cellular Networks with Lab — Credits: 2 + 1

Prerequisites: Computer Networks II and Introduction to Wireless Networks, GSM/GPRS/EDGE, LTE/LTE-A. Scheduling algorithms, handover management, ICIC, Small Cells, HetNets, etc.

References:

- Mobile Communications by Jochen Schiller, 2nd edition, 2003, Addison-Wesley
- 4G LTE/LTE-Advanced for Mobile Broadband by Erik Dahlman, Stefan parkvall, Johan Skold, Academic Press, 2011.
- 3GPP specs.
- Online Resources: www.3gpp.org, http://www.eventhelix.com/lte/lte-tutorials.htm, https://moodle.iith.ac.in/

CS3490: Wireless LANs — Credits: 2 (+1 for Lab)

Prerequisites: Computer Networks II and Introduction to Wireless Networks, Generations of Wireless LANs: 802.11 a/b/g/n/ac/ad. QoS enhancements: 802.11e, Wi-Fi security, Rate adaption, Power control, Power saving, Dynamic Frequency selection, various usages of RTS/CTS handshake, Frame aggregation, TXOP.

References:

- Mobile Communications by Jochen Schiller, 2nd edition, 2003, Addison-Wesley
- Ad hoc Wireless Networks: Architectures and Protocols by C. Siva Ram Murthy and B. S. Manoj, Prentice Hall, 2004.
- IEEE 802.11 specs.

CS4540: Topics in Program Analysis and Programming Languages — Credits: 2

Prerequisites: Compilers II and POPL II, Program analysis, Programming language semantics, Lattices, Abstract interpretation, Pointer analysis, Type checking, Model checking.

References:

- John Mitchell, Foundations of Programming Languages, MIT Press, 1996; papers from literature.

CS4590: Topics in Networks — Credits: 2

Prerequisites: Computer Networks II and/or Wireless LANs and/or Cellular Networks Research based course primarily based on recent advances in core computer networking technologies and/or mobile wireless networks like Software Defined Networking, Future Internet, Cloud RAN, 5G, Convergence of Heterogeneous wireless technologies, M2M/ IoT, etc. The objective is to propose extensions, implement them on a testbed/NS-3 platform, and publish the results.

References:

- Research papers, NS-3 network simulator, OpenAirInterface.
- Online Resources: http://www.nsnam.org/, https://moodle.iith.ac.in/

CS5010: Neural Networks — Credits: 3

Introduction to ANNs: Biological neural networks, Pattern recognition tasks, computational models of neurons; Learning principles; Feed forward and feedback neural networks: Perceptron, back propagation learning, regularization theory, RBF networks for function approximation and pattern classification; Support vector machines, self–organizing maps, pattern storage and retrieval, Hopfield model, Recurrent neural networks.

References:

- B. Yegnanarayana, Artifical Neural Networks, Prentice Hall of India,1999
- Satish Kumar, Neural Networks – A Classroom Approach, Tata Mc Graw-Hill, 2003
- S. Haykin, Neural Networks – A Comprehensive Foundation, Prentice Hall, 1998

CS5020: Pattern Recognition — Credits: 3

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.

References:

- R.O. Duda, P.E. Hart and D.G. Stork, Pattern Classification, John Wiley, 2001
- S.T heodoridis and K. Koutroumbas, Pattern Recognition, 4th Ed., Academic Press, 2009
- C.M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006

CS5030: Topics in Theoretical Computer Science — Credits: 3

Prerequisites: Undergraduate courses in Data Structures and Algorithms, theory of computation. This course will be primarily based on published papers in various areas of theoretical computer science. The objective is to discuss in depth some of the key results in theoretical computer science.

CS5050: Advanced Topics in Data Management — Credits: 3

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.

References:

- Mainly published research papers

CS5060: Advanced Computer Networks — Credits: 3

Prerequisites: Undergraduate course on 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.

References:

- Computer Networking: A Top-Down Approach by James F. Kurose and Keith W. Ross, 5th Edition, 2009, Addison Wesley
- Research articles on above mentioned course contents

CS5070: Networked Wireless Systems — Credits: 3

Fundamentals of Wireless Communication, Wireless LANs, Cellular Systems, Mobile Ad hoc Networks, Routing in Mobile environments, Medium Access Control (MAC), Capacity of Wireless networks, Cross-layer design, Cognitive Networking, and Project demos/presentations.

Prerequisites: Undergraduate course on Computer Networks.

References:

- Mobile Communications by Jochen Schiller, 2nd edition, 2003, Addison-Wesley; research articles

CS5080: Algorithms for VLSI Physical Design Automation — Credits: 3

Data Structures and Basic Algorithms, Partitioning Algorithms, Floor Planning Algorithms, Routing Algorithms.

Prerequisites: C++ Programming

References:

- ALGORITHMS FOR VLSI PHYSICAL DESIGN AUTOMATION by Naveed A. Sherwani
- Combinatorial Algorithms for Integrated Circuit Layout- Thomas Lengauer

CS5100: Quantum Computing — Credits: 3

Preliminaries: linear algebra, postulates of quantum mechanics, no cloning theorem; models of Quantum Computation: Quantum Turing Machines, Quantum Circuits; Hidden Subgroup Problem, Shor's algorithm for integer factoring; Grover's algorithm for unordered search; introduction to Quantum Cryptography; quantum lower bounds, quantum random walks, quantum communication.

References:

- Michael Nielsen and Isaac Chuang: Quantum Computation and Quantum Information; research papers

CS5110: Computational Complexity — Credits: 3

Review of Undecidability, Diagonalization, Time and Space Hierarchy theorems, Oracles, Relativization, Baker Gill Solovay theorem; review of NP-completeness, types of reductions, Space Complexity, Savitch's theorem, Immerman Szlepcsenyi theorem, Polynomial Hierarchy, Introduction to Circuit Complexity, Interactive Proof Systems, Counting Classes: #P, Toda's theorem.

References:

- Christos Papadimitrious; Computational Complexity; Addison Wesley
- Sanjeev Arora and Boaz Barak; Computational Complexity: A Modern Approach; Cambridge University Press

CS5113: Network Engineering — Credits: 3

Introduction to network engineering, Cabling, Wireless Networks, VLAN Management, IPv4/v6 Addressing, Network Configuration at End Systems, Network Topology, Intra-AS Routing, Inter-AS Routing and Traffic Control, Multicast Routing and Video Streaming, Benchmarking and Monitoring, Security, Designing Enterprise Networks.

References:

- Network Warrior, 2nd Edition by Gary A. Donahue, ISBN-13:978-1-4493-8786-0, O'Reilly Media, 2011.
- Computer Networking: A Top-Down Approach, 6/E by James F. Kurose and Keith W. Ross, ISBN-13: 9780132856201, Pearson Education, 2012.

CS5120: Probability in Computing — Credits: 3

Review of probability theory: random variables, expectation, conditional probability; randomized algorithms: min-cut and quick sort, models of randomized computation and randomized complexity classes; Tools: Moments and deviations, Markov and Chebyshev Inequalities, Chernoff bound, applications; hashing, Markov chains and random walks, applications and other topics.

References:

- Rajeev Motwani and Prabhakar Raghavan; Randomized algorithms; Cambridge University Press
- Michael Mitzenmacher and Eli Upfal; Probability and computing; Cambridge University Press

CS5130: Cryptography — Credits:3

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.

References:

- Douglas B. Stinson – Cryptography – Theory and Practice 2nd or 3rd Edition; CRC Press
- A course in number theory and cryptography – Neal Koblitz; Springer
- Applied Cryptography – Bruce Schneier, 2nd Edition; Wiley and Sons

CS5190: Soft Computing — Credits: 3

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.

References:

- S. Haykin, Neural Networks: A Comprehensive Foundation, Pearson Education, 1999.
- B. Yegnanarayana, Artificial Neural Networks, PHI, 1999.
- J.-S.R. Jang, C.-T. Sun, and E. Mizutani, Neuro-Fuzzy and Soft Computing: A Computational Approach to Learning and machine Intelligence, Pearson Education, 1997.

CS5200: Machine Learning — Credits:3

Classification, clustering - fuzzy c-means and hierarchical, decision surfaces, parameter estimation methods, Bayesian decision theory, Markov models, HMMs, dimension reduction methods, principal component analysis, SVD, Fisher discriminant analysis, perceptrons, support vector machines, unsupervised learning and k¬-means clustering, non-parametric methods, applications in real world.

References:

- R. O. Duda, P. E. Hart and D. G. Stork, "Pattern Classification", John Wiley, 2001
- 2. S. Theodoridis and K. Koutroumbas, "Pattern Recognition", 4th Edition, Academic Press, 2009
- C. M. Bishop, "Pattern Recognition and Machine Learning", Springer, 2006.

CS5210: Introduction to Compiler Optimizations — Credits: 3

Prerequisites: Compilers II, Control-Flow and Data-Flow analyses, Intermediate representations, Static Single Assignment (SSA) representation, Optimizations using SSA representations, Constant propagation, Register allocation, Instruction scheduling, Software pipelining, Dependence analysis and dependence representations, Unimodular transformations.

References:

- Alfred V. Aho, Monica S. Lam, Ravi Sethi, Jeffrey D. Ullman, Compilers: Principles, Techniques, and Tools, Addison-Wesley, 2007.
- Steven S. Muchnick: Advanced Compiler Design and Implementation. Morgan Kaufmann 1997.
- Randy Allen, Ken Kennedy: Optimizing Compilers for Modern Architectures: A Dependence-based Approach. Morgan Kaufmann 2001.

CS6140: Video Content Analysis — Credits: 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.

References:

- Video Content Analysis using Multimodal information, Ying Li, Kuo, C.C. Jay, Springer, 2003.
- The Essential Guide to Video Processing, Al Bovic, Second Edition, Elsevier Academic Press, 2009.
- Computer Vision: Algorithms and Applications, Richard Szeliski, Springer, 2010.

CS6200: Automatic Parallelization — Credits: 3

Prerequisites: Compilers II, Dependence Analysis, Dependence abstractions, The polyhedral model, Polyhedra as dependence representations, Affine scheduling and code generation.

References:

- David A. Padua (Ed.): Encyclopedia of Parallel Computing. Springer 2011
- Randy Allen, Ken Kennedy: Optimizing Compilers for Modern Architectures: A Dependence-based Approach. Morgan Kaufmann 2001.
- Alain Darte, Yves Robert, and Frédéric Vivien. Scheduling and Automatic Parallelization. Birkhaüser, 2000.

DEPARTMENT OF DESIGN

DD1014: Let's Make a Graphic Novel — Credit: 1

PREREQUISITES: love of graphic novels and the desire to make one COURSE OUTLINE: The graphic novel is a form of story-telling that finds many avid readers not only amongst teenagers but also much older age groups. This elective provides scope for and guides the development of a graphic novel, for the readers who want to try their hands at making one. The course is designed in the workshop-mode to allow the participants to be aware of the nature of the graphic novel through a handful of basic elements and their deployment to create a graphic novel. The elective breaks down this form of the novel primarily into 5 elements: story, narration, visuals, text and impact. The intention is to enable the participant to consciously modulate them. The aim of the course is to bring out and make the participant engage with the qualities of narratives and the forms in which they are expressed and employed.

Reading Material:

- Sacco, J (2001), Palestine, Fantagraphics
- Satrapi, M (2007), Persepolis, Pantheon
- Speigelman, A (2003), Maus, Penguin
- Quinn, J; Tayal, A (2012), Steve Jobs: Genius by Design, New Delhi: Campfire

DS1001: Always Carry Your Camera — Credit: 1

Course Outline: Learning the skill of photography, Aesthetic appreciation of the medium of photography, Improving visual awareness (Visual awareness would involve a process of familiarizing oneself to the subject in its widest context to be able to make the optimum use of this medium in recording and communicating activity / Environment etc., through photography),To expose the participants to the fundamentals of photography as a tool for documentation and presentation, To develop an aesthetic quality with reference to "composing a picture" with all its elements such as texture, light, form and space etc. Introduction to Digital Photography.

Reading Material:

- Photography foundations for art and design:
- The creative photography handbook. 4th ed. Galer, Mark, Focal Press. Principles of Design through Photography-Deepak J Matthew,wisdom tree
- THE PHOTOGRAPHIC IMAGE IN DIGITAL CULTURE, Lister, Martin, COMPLETE DIGITAL PHOTOGRAPHY, Ang, Tom,London New Holand Publishers 2005.

DEPARTMENT OF ELECTRICAL ENGINEERING

EE1010: Electric Circuits — Credit: 1

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.

Reading Materials:

- Signals and Systems, by Hayt and Kemmerley
- Signals and Systems, by Oppenheim, Wilsky and Young

EE1020: Magnetic Circuits

Coupled circuits, Transformers.

Reading Materials:

- Signals and Systems, by Hayt and Kemmerley
- Signals and Systems, by Oppenheim, Wilsky and Young

EE2511/EE2011 (2013): Basic Electrical Engineering Lab

RLC networks/filters, Transformers, Operational Amplifiers, Project.

EE1300/EE 1097 (2013): Digital Signal Processing (DSP) — Credit: 1

Sampling, continuous and discrete-time transforms, z-transforms, finite impulse response (FIR) and infinite impulse response (IIR) filter design, FFT algorithm.

Reading Materials:

- Discrete-time signal processing, by Oppenheim and Schaffer

EE1220/EE 1437 (2013): Basic Control Theory — Credit 1

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.

Reading Materials:

- Control Systems Engineering by I.J. Nagrath and M. Gopal
- Automatic Control Systems by B.C. Kuo
- Control System Engineering by Norman S. Nise

EE1110/EE1027 (2013): Boolean Algebra — Credit: 1

Number systems and codes, Representation of tin and signed integers, Fixed-point representation of real numbers, Floating point representation of real numbers, Representation of character data, Representation of signals, Laws of Boolean algebra, Theorems of Boolean algebra, switching functions, Methods for specification of switching functions - Truth table and Algebraic forms, Realization of functions using logic gates, Electronic logic gates, Positive and negative logic, Realization of logic gates, Simplification of Boolean Expressions and Functions, Algebraic methods, Canonical forms of Boolean functions, Minimization of functions using Karnaugh maps, minimization of functions using Quine-McClusky method

Reading Materials:

- Digital Design by Morris Mano
- Steven R. Givant; Paul Richard Halmos, Introduction to Boolean algebras.
- Koppelberg, Sabine. "General Theory of Boolean Algebras". Handbook of Boolean Algebras, Vol. 1

EE2120/EE 1067 (2013): Computer Organization — Credit: 1

Introduction to computers, Computer generations, number representation, fixed point arithmetic, ALU organization, floating point arithmetic, FPU, Decimal (BCD) arithmetic, Instruction formats and addressing modes, Hardwired and Micro-programmed control units, Memories and memory interfacing, System busses, Peripheral interfaces, I/O modes: Programmed, Interrupt, DMA, I/O processor, Basic CPU design,,

Reading Materials:

- Computer Architecture: A Quantitative Approach, by Hennessy and Patterson
- Digital Design, by Morris Mano

EE2110/EE2027: Digital Systems and Design — Credit: 1

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, Programmable Read Only Memories (PROMs), Programmable Logic Arrays (PLAs), Programmable Array Logic (PAL) devices, Sequential circuits - Latches, Flip-flops, Master-slave flip flops, Edge-triggered 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

Reading Materials:

- Digital design principles and practises, by J F Wakerley

EE1320/EE1077 (2013): Signals and Communication — Credit: 1

Introduction: The communication process, Sources of information,Communication channels, Baseband and passband 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.

Reading Materials:

- Communication Systems, by Simon Haykin
- Communication System Design, by Proakis and Salehi
- Signals and Systems, by Oppenheim, Wilsky and Young

EE1310/EE1057 (2013): Data Analytics — Credits: 2

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.

Reading Materials:

- Introduction to Probability, by Sheldon Ross

EE1510/EE1047 (2013): Matrix Analysis — Credit: 1

Matrices and vectors, determinants, singularity of matrices, rank, Eigenvalues, eigenvectors, and invariant subspaces, Vector norms and matrix norms.

Reading Materials:

- A. R. Bellman, Introduction to Matrix Analysis, SIAM

EE1080/EE 1427 (2013): Semiconductor Fundamentals — Credit: 1

Valence band and Energy band models of intrinsic and extrinsic semiconductors, Thermal equilibrium carrier concentration, Fermi-Dirac distribution, Carrier transport by drift, resistivity, Excess carriers, lifetime, carrier transport by diffusion, Continuity equation. P-N Junction, structure, I-V characteristics, Forward and Reverse bias. Bipolar junction transistor: Structure,DC input and Output characteristics, Application as amplifier and switch. MOSFET: Structure, DC input and Output Characteristics, Applications.

Reading Materials:

- Semicondcutor Devices By Sim Dimitrijev
- Solid state electronic devices By Streetman and Banerjee
- Semiconductor Device Fundamentals By Robert. F. Pierret

EE1170/EE1447 (2013): Embedded Programming — Credit: 1

Concepts of 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.

Reading Materials:

- Microprocessor architecture, programming and applications, by Ramesh Gaonkar
- Verilog HDL, by Palnitkar
- VHDL programming, by Douglas Perry

EE2010/EE2107 (2013): Device Physics — Credits: 2

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.

Reading Materials:

- Solid State Electronic Devices, Streetman and Banerjee
- Semiconductor Device fundamentals: Robert F. Pierret

EE2020: Microprocessors and Computer Organization

Introduction to computers, Computer generations, number representation, fixed point arithmetic, ALU organization, floating point arithmetic, FPU, Decimal (BCD) arithmetic, Instruction formats and addressing modes, Hardwired and Microprogrammed control units, Memories and memory interfacing, System busses, Peripheral interfaces, I/O modes: Programmed, Interrupt, DMA, I/O processor, Basic CPU design,, Advances in computer architecture, super scalar processors, Virtual memory concept, Multiprogramming and multi-tasking, RISC vs CISC

Reading Materials:

- Computer Architecture: A Quantitative Approach, by Hennessy and Patterson
- Digital Design, by Morris Mano
- Microprocessor architecture, programming and applications, by Ramesh Gaonkar

EE2320/EE2017 (2013): Digital Modulation Techniques — Credit: 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

Reading Materials:

- Digital Communications, by J G Proakis

EE2310/EE 2007 (2013): Information Science — Credit: 1

Information, discrete memoryless source, entropy, mutual information, capcaity, source and channel coding theorems, shannon's capacity formula, rate-distortion theorem, differential entropy.

Reading Materials:

- Digital Communications, by Simon Haykin

EE2300/EE2037 (2013): Advanced DSP — Credits: 2

Frequency Domain Analysis of LTI Systems, Implementation of FFT, algorithms, Filter Design: IIR and FIR filters, Multi-rate signal processing: sampling rate conversion.

Reading Materials:

- Discrete-time signal processing, by Oppenheim and Schaffer

EE2200/EE2207 (2013): Transformers and DC Machines — Credits: 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.

EE2510/EE2047 (2013): Graph Theory — Credit: 1

Terminologies and definitions (such as, nodes, elements, tree, cotree, branch, link, path, connected graph, oriented graph, loop, basic loop, cut-set, basic cut-set, tie cut-set) in graph theory; graph theoretic matrices (such as, element-node incidence matrix, branch-path incidence matrix, loop incidence matrix, cut-set incidence matrix); basic properties of a graph; graph theoretical approach for electrical circuit analysis; some interesting problems in graph theory (such as, minimum spanning graph determination and the travelling salesman problem).

Reading Materials:

- N. Deo, Graph Theory with Applications to Engineering and Computer Science. New Delhi: PHI Learning, 2009.

EE2090/EE2057 (2013): Antenna Design — Credit: 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.

Reading Materials:

- Constantine A. Balanis, Antenna Theory: Analysis and Design, April 4, 2005. 2. Elliott, Robert S., Antenna Theory and Design, Wiley-IEEE Press, 2003.

EE2240/EE2067 (2013): Renewable Energy Driven Power Systems — Credit: 1

Primary attributes of different renewable energy sources; power electronic interfaces; concept of maximum power point tracking; different energy storage options and their operating principles; concept of load shifting; utilizations of storage devices and load shifting to deal with the non-uniformity of energy availability.

Reading Materials:

- M. A. El-Sharkawi, Electric Energy: An Introduction. Boca Raton, FL: CRC Press, 2008.
- S. Chowdhury, S. P. Chowdhury, and P C rossley, Microgrids and Active Distribution Networks. UK: IET, 2009.
- A. Yazdani and R. Iravani, Voltage-Sourced Converters in Power Systems.: Modeling, Control, and Applications. New Jersy: Wiley, 2010.

EE2230/EE 1087 (2013): Smart Grid — Credit: 1

Syllabus: 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.

Reading Materials:

- C. L. Wadhwa, Electrical Power Systems. New Delhi: New Age International Publishers.

EE2250/EE2077 (2013): Optimization — Credit: 1

Syllabus: Review of unconstrained optimization; introduction to constrained optimization; KKT necessary and sufficient conditions of optimality; principle of duality; sensitivity analysis; linear programming.

Reading Materials:

- M. S. Bazaraa, H. D. Sherali, and C. M. Shetty, Nonlinear Programming: Theory and Algorithms. New Jersey: John Wiley, Apr. 2006.
- A. D. Belegundu, and T. R. Chandrupatla, Optimization Concepts and Applications in Engineering, Cambridge: Cambridge University Press,2011.
- R. Baldick, Applied Optimization: Formulation and Algorithms for Engineering Systems. Cambridge: Cambridge University Press,2006.
- S. Boyd and L. Vandenberghe, Convex Optimization. Cambridge: Cambridge University Press, 2006.

EE2260/EE2217 (2013): AC Machines — Credit: 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.

Reading Materials:

- D. P Kothari and I. J. Nagrath, Electric Machines. New Delhi: Tata McGraw-Hill.
- E. Fitzgerald, C. Kingsley, Jr., and S. D. Umans, Electric Machinery. New Delhi: Tata McGraw-Hill.
- L. Kosow, Electric Machinery and Transformers. New Delhi: Pearson Education.

EE2210/EE2087 (2013): Power Electronics — Credit: 1

The basics of power electronic switches, introduction to AC – DC (uncontrolled), Non-isolated DC – DC converters and single phase Inverters.

Reading Materials:

- Ned Mohan, William P. Robbins, Tore M. Undeland, “Power Electronics: Converters, Applications and Design”, Media Enhanced 3Rd Ed, Wiley India Pvt Ltd (January 2007)
- L. Umanand, “Power Electronics: Essentials and Applications”, Wiley India Pvt Ltd (April 2009)

EE2360/EE2097 (2013): Introduction to Multimedia — Credit: 1

Image compression fundamentals - Huffman, arithmetic coding, DCT and wavelet based compression. Video compression fundamentals - motion compensated prediction, prediction structures. Applications.

Reading Materials:

- Digital Image Processing by Gonzalez and Woods, Prentice Hall, 3rd Edition

EE2380/EE2407 (2013): Channel Coding — Credit: 1

Basic concepts: error correction, error detection, and erasure correction, linear error-correcting codes; Hamming codes, Introduction to finite fields, convolution codes and coded modulation, LDPC and Turbo codes.

Reading Materials:

- R.M. Roth, Introduction to Coding Theory, Cambridge University Press, Cambridge, UK, 2006.
- R.J. McEliece, The Theory of Information and Coding, Second Edition, Cambridge University Press, Cambridge, 2002.
- Lin, D.J. Costello, Jr., Error Control Coding: Fundamentals and Applications, Second Edition, Prentice-Hall, Upper Saddle River, New Jersey, 2004.

EE2130/EE2417 (2013): Advanced Analog Electronics — Credits: 2

Operation Amplifiers: Push-Pull Amplifiers, Differential Amplifiers, Operational amplifiers, Feedback Amplifiers: Series-Shunt, Shunt-Shunt, Voltage-Voltage FB, Voltage Current FB, etc. their stability and frequency response, Analog Filters: Filter Characteristics, Low, High pass Butterworth, Cheybyshev etc, Supply and Sources for IC: Rectifier, Regulator, Current sources, Voltage sources, Noise and Linearity.

Reading Materials:

- Fundamentals of Microelectronics by Behzad Razavi, Wiley Indian Addition
- Microelectronic Circuits by Sedra and Smith, Revised 5th Edition, Oxford University Press

EE2140/EE2437 (2013): CMOS Fabrication — Credit: 1

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.

Reading Materials:

- Silicon VLSI Technology: Fundamentals, Practise and Modeling,James D. Plummer, Micheal Deal, Peter D Griffin.

EE2220/EE2227 (2013): Control Systems — Credits: 2

Course Content: Classical control systems, optimal control systems, nonlinear systems, adaptive control, fuzzy logic control, neural networks.

Reading Materials:

- Fuzzy and Neural Control by Robert Babuska
- Adaptive Control by Åström, Karl J. and Wittenmark, Björn
- Nonlinear Systems by Hassan Khalil
- Nonlinear Systems Analysis by M. Vidyasagar

EE2520/EE2447 (2013): Computer Networks — Credit: 1

OSI Model, Fundamentals of TCP and UDP, Client-server programming, peer-to-peer communication.

Reading Materials:

- Andrew S. Tanenbaum, “Computer Networks”, 4th ed., Prentice Hall, 2003.

EE3310/EE3307 (2013): Random Processes — Credits: 2

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.

Reading Materials:

- Probability, Random Variables and Stochastic Processes, A. Papoulis.

EE3210/EE3207 (2013): Power Electronics Analysis and Design — Credit: 1

Analysis of Controlled and uncontrolled rectifiers, modelling of DC-DC converters, three phase Inverters, PWM techniques.

Reading Materials:

- Ned Mohan, William P. Robbins, Tore M. Undeland, "Power Electronics: Converters, Applications and Design", Media Enhanced 3Rd Ed, Wiley India Pvt Ltd (January 2007)
- L. Umanand, "Power Electronics: Essentials and Applications", Wiley India Pvt Ltd (April 2009)

EE3030: Digital Chip Design

Concept of digital chip design: coding to tape-out, front-end design: high level synthesis, translation, optimization, mapping, linting; Back-end design: floor-planning, placement, routing, clock-tree synthesis; Verification: dynamic, static, formal; DFT; Low-power design methodologies; Emulation: FPGA and hardware Emulator based; learning design using CAD tools: sign-off quality.

Reading Materials:

- Application Specific Integrated Circuits, by Smith
- Digital integrated Circuits, by Jan. M. Rabaey
- Digital Arithmetic, by Ercegovac and Lang

EE3240/EE3217 (2013): Power System Practice — Credits: 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.

Reading Materials:

- C. L. Wadhwa, Electrical Power Systems. New Delhi: New Age International Publishers.
- J. J. Grainger and W. D. Stevenson, Jr., Power System Analysis. New Delhi: Tata McGraw-Hill.
- H. Saddat, Power System Analysis. New Delhi: Tata McGraw-Hill.

EE3320/EE3007 (2013): Cellular Networks — Credit: 1

Link budget, propagation models, statistical channel models, SINR, distribution in a cellular network; multiple access methods: TDMA, FDMA, CDMA, OFDMA. Link level analysis: synchronization, equalization and channel estimation for SC-FDMA and OFDM, Introduction to 4G LTE, Pilot design, CQI reporting, Control channel design, power control, Hybrid ARQ, Scheduling, Overview of Macro, Pico, and Femto cell operation, Link and system simulation methodologies.

Reading Materials:

- Foundations of Mobile Radio Engineering, Michael Daoud Yacoub, CRC Press

EE2020/EE2037 (2013): Linear Electronics — Credit: 1

Introduction to Analog Circuits and Application, Basic Amplifiers: Bias, Small Signal Model, Gain Calculation, Design Example for Specified Gain and Swing Frequency response of Amplifiers:– Simple RC Circuits Amplifier Low-Frequency Response, Low-Frequency and High-Frequency Model and Response Inverters: Mixed mode behavior.

Reading Materials:

- Microelectronic Circuits by Sedra and Smith, Revised 5th Edition, Oxford University Press

EE2010: Electrical and Magnetic Circuits

Introduction to basic circuit elements: Dependent voltage source, independent voltage source, dependent current source, independent current source, resistors, inductors, capacitors, mutually coupled coils. DC circuit analysis: Kirchoff's voltage law, Kirchoff's current law, mesh analysis, nodal analysis. Introduction to network theorems: Superposition theorem, Thevenin's theorem. Norton's theorem, Reciprocity theorem, Maximum Power Transfer theorem, Tellegen's theorem, Millman's theorem, Compensation theorem. Transient analysis of R-L-C circuits: Differential equation, initial condition, time constant, overdamped response, underdamped response, critically damped response, concept of state variables, duality. Introduction to basic OP-AMP circuits: Inverting amplifier, non-inverting amplifier, adder, differentiator, integrator, analog computer. Steady state AC circuit analysis: Phasor representation, impedance, admittance, reactance, active power, reactive power, power factor, maximum power transfer theorem for AC circuits. Three phase AC circuit analysis: Star connection, Delta connection, Star-Delta conversion, power in three phase circuits, balanced three phase circuit, unbalanced three phase circuit, symmetrical components, power measurement in balanced three phase circuits. Frequency response: Quality factor, series resonance, parallel resonance, Bode plot, frequency scaling, magnitude scaling. Two port network: Port condition, different representations of a two-port network, T-equivalent, pi-equivalent, series connection, parallel connection, cascade connection. Magnetic circuits: Magneto-motive force, reluctance, permanent-magnet magnetic circuit, B-H curve, hysterisis loop, eddy current loss.

Reading Materials:

- W. Hayt, J. E. Kemmerly, and S. M. Durbin, Engineering circuit analysis. New Delhi: Tata Mcgraw Hill.
- K. V. V. Murthy and M. S. Kamath, Basic current analysis. Noida: Jaico Publishing House.
- M. E. Van Valkenburgh, Network Analysis. India: Prentice Hall.
- V. Del Toro, Electrical Engineering Fundamentals. New Delhi: Pearson Edition.
- M. Nahvi and J. Edminister, Electric Circuits. New Delhi: Tata McGraw-Hill.

DEPARTMENT OF LIBERAL ARTS

LA1047: Introduction to the Short Story — Credit: 1

Designed for the beginning student of literature, this course provides an overview of the traditional and modern approaches of narration used by the short story genre. By reading a selection of short literary narratives by writers such as Maupassant, Tagore and Marquez, among others, this course examines how plot and authorial intent shape short stories. The students are expected to read and critically interpret these narratives and submit their responses in the form of both oral and written presentations.

Reading material:

- Charters, Ann. The Story and Its Writer: An Introduction to Short Fiction. Sixth Edition. Bedford/St. Martin, 2003.
- Fallon, Erin, R.C. Fedderson, James Kurtzleben, Maurice A. Lee, and Susan Rowchette-Crawley (Eds.) A Reader's Companion to the Short Story in English. NY: Greenwood Press, 2000.

LA1057: Cultures of the World — Credit: 1

This course will introduce students to the field of social and cultural anthropology and sociology. 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.

Reading material:

- Cultural Anthropology, 6th edition, by Barbara Miller. Pearson publishers. 2010.
- Imagining America: Stories from the Promised Land (ed). 2nd edition. W.W.Norton and Co. 2003.
- The Harmless People. By Elizabeth Marshall Thomas. 1989. Knopf Doubleday.

LA1067: Origin of Ethics in Political Theory — Credit: 1

First philosophical contemplations about abstract ethical notions like virtue, truth, valor, wisdom, love etc took place in ancient Greece in 6th century BC. This course explains to students the importance of looking at how and why they originated and more importantly what they were like in their nucleus form. 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.

LA1077: Psychology of Interpersonal Relationships — Credit: 1

We are social creatures and are in constant need to relate and orient ourselves towards animate beings. This course is 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 to explore various aspects of human relationships.

Reading material:

- Reis, H.T., Collins, W.A., and Berscheid, E. (2000). The relationship context of human behavior and development. Psychological Bulletin, 126, 844-872.
- Eastwick, P.W., and Finkel, E.J. (2008). Sex Differences in Mate Preferences Revisited: Do People Know What They Initially Desire in a Romantic Partner? Journal of Personality and Social Psychology, 94, 245–264.

LA1087: Sociology of Digital Media — Credit: 1

New Media technologies are products of the digital revolution and are rapidly transforming the 'everyday' life of societies and individuals. These have enabled new channels of information, social networking, and commerce and more importantly, the creation of a virtual life. The course is intended to contribute to an understanding of the individual and society through the use of new digital media tools [example the internet, social media, mobile phone technologies and devices] and theoretically informed case studies centering on people in cross-cultural, resource-poor and emerging market settings [for example, developing countries, the urban slum etc…].

Reading material:

- Turkle, S. (1984) The Second self. New York: Simon and Schuster.
- Boyd, Danah (2014) It's Complicated: The Social Lives of Networked Teens. New Haven: Yale University Press.

LA1097: Introduction to Mind and Body Interaction — Credit: 1

This course will study engagements between the 'bodily' and the 'mental' by using three important concepts: sites, technologies and performance. We will look at the impact of different sites of mind/body healing (clinics, asylums, temples, etc.) as well as the role of new biomedical technologies (e.g. organ transplants and medical implants) in producing important changes in bodily experiences. We will also examine the use of performance, theatre, dance, etc. in engaging with mind. Classes will be interactive and evaluation will be assignment-based.

Reading material:

- Samuel, G. (1990). Mind, Body and Culture: Anthropology and the Biological Interface. Cambridge: Cambridge University Press.
- Rose, N. (2007). The Politics of Life Itself: Biomedicine, Power, and Subjectivity in the Twenty-First Century. Princeton: Princeton University Press.

LA2017: Psychology of Happiness — Credit: 1

Happiness is one of the most popular topics in positive psychology which focuses on strengths as opposed to the deficit based approach of traditional psychology. This course will introduce the latest research in the area including positive emotions, character strengths, meaningfulness and resilience; and their relation to happiness will be examined. Positive psychology interventions that enhance happiness will be explored.

LA2027: Introduction to International Finance — Credit: 1

This course will provide an introduction to basic aspects of international finance. Topics covered include open economy macroeconomics and balance of payments, exchange rates and the foreign exchange market, forward market and foreign exchange risk, inflation and exchange rate, output and exchange rate, and exchange rate regimes.

Reading material:

- Main Texbook: International Economics: Theory and Policy by Paul Krugman and Maurice Obstfeld (Pearson's Publication)
- Additional Reading: International Finance by Maurice D. Levi (Routledge)

DEPARTMENT OF MATERIALS SCIENCE AND METALLURGICAL ENGINEERING

MS1050: Physics of Solids — Credit: 1

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.

Reading materials:

- Introduction to solid state physics, Charles Kittel, John Wiley and sons
- Physical Chemistry, J.D Lee

MS1070: Semiconductor Materials — Credit: 1

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.

Reading materials:

- Introduction to solid state physics, Charles Kittel, John Wiley and sons
- Physics of Semiconductor Devices, S.M.Sze

MS1010: Science and Engineering of Materials — Credit: 1

Concepts of metallurgy and materials science, types of materials (metals, ceramics, polymers, hybrids), material properties (structural and functional), application orientated material design, some case studies: biomaterials, automotives, aerospace, etc.

Reading Materials:

- Ashby, Michael F., Hugh Shercliff, and David Cebon, Materials: Engineering, science, processing and design, Butterworth-Heinemann, 2013.
- Dieter, George Ellwood. Engineering Design- a materials and processing approach. McGraw-Hill, 1983.

MS2020: Physical Metallurgy — Credits: 2

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.

Reading materials:

- R. Abbaschian, R. Reed-Hill, Physical Metallurgy Principles, Cengage Learning, 2008.
- S.H. Avener, Introduction to Physical Metallurgy, Tata McGraw-Hill.
- G.E. Dieter, Mechanical Metallurgy, McGraw-Hill.

MS1020: Metallic Materials — Credits: 1

Structure of metals, Determination of structure and chemical composition, concepts of alloys, phase and phase diagrams.

Reading materials:

- W.D. Callister, “Fundamentals of Materials Science and Engineering”, 2001, John Wiley and Sons, NY, USA.
- R. Abbaschian, R. Reed-Hill, Physical Metallurgy Principles, Cengage Learning, 2008.
- S.H. Avener, Introduction to Physical Metallurgy, Tata McGraw-Hill.

MS1030: Materials Characterization-I — Credit: 1

Spectroscopic techniques: Vibrational spectroscopy (IR and Raman); visible and UV spectroscopy; NMR and ESR; X-ray spectroscopies (EDS, WDS), AEFS, EXAFS; Electron spectroscopies (ESCA, XPS, UPS, AES, EELS); Mössbauer spectroscopy. **Microscopic techniques-** Optical microscopy, AFM. **Thermal analysis-** TGA, DTA, DSC, Electrical and magnetic measurements

Reading materials:
- Solid state chemistry and its applications, Wiley (2003) by Anthony R. West
- Materials characterization: Introduction to microscopic and spectroscopic methods, 2nd ed., Wiley (2013) by Yang Leng
- Encyclopaedia of materials characterization, Butterworth-Heinemann (1992) by C. Richard Brundle, Charles A. Evans Jr. and Shaun Wilson

MS1040: Materials Synthesis — Credit: 1

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

Reading materials:
- Inorganic Materials Synthesis and Fabrication; John N. Lalena, David A. Cleary, Everett Carpenter – Wiley 2008
- Chemical approaches to the synthesis of inorganic materials, C. N. R. Rao, Wiley, 1994

MS1060: Polymers — Credit: 1

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, application, processing techniques and product development

Reading material:
- Young, Robert J., and Peter A. Lovell. Introduction to polymers. CRC press, 2011.

MS1080: Computational Methods in Materials Science-I — Credit: 1

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.

Reading materials:
- E. Kreyszig and E.J. Norminton, “Advanced Engineering Mathematics: Mathematica Computer Manual” 8th edition, 2001
- R. LeSar, “Introduction to Computational Materials Science: Fundamentals to Applications” CUP, 2013

MS1090: Micro-mechanics of Solids — Credit: 1

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: Soft Matter Science — Credit: 1

Colloids, foams, gels, surfactants soft biological materials such as DNA, liquid crystals – structure, property, characterization and applications, theoretical concepts.

Reading Material:
- Hirst, Linda S. Fundamentals of soft matter science. CRC Press, 2012.
- Hamley, Ian W. Introduction to soft matter: synthetic and biological self-assembling materials. John xWiley and Sons, 2008.
- Berti, Debora. “Introduction to Soft Matter.” (2008): 1073-1073.

MS2040: Advanced Materials Synthesis — Credits: 2

Nucleation and growth processes in solution based synthesis, Solid liquid interface interactions, reaction conditions effect on morphology, Nanomaterial synthesis, Sintering process basics- chemical reaction and phase transformation kinetics, Substrate-vapour interactions and effect of deposition conditions on growth and morphology in CVD, PVD.

Reading materials:

- Inorganic Materials Synthesis and Fabrication; John N. Lalena, David A. Cleary, Everett Carpenter – Wiley 2008
- Chemical approaches to the synthesis of inorganic materials, C. N. R. Rao, Wiley, 1994

MS2050: Mechanical Behaviour of Materials — Credits: 2

Hardness testing, Tensile and compression testing, Torsion testing, Fatigue testing, Fracture, High temperature deformation- Creep and superplasticity, Impact testing and failure

Reading materials:

- G.E. Dieter, Mechanical Metallurgy, McGraw-Hill.
- M.A. Meyers, K.K. Chawla, Mechanical Metallurgy: Principles and applications, Prentice-Hall.

MS2070: Ceramics and Refractories — Credit: 1

Introduction, Ceramic Materials: structure, microstructure and polymorphism, synthesis 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.

Reading materials:

- Introduction to ceramics, W.D Kingery, Wiley publishing (1966)
- Refractory Materials, G. B. Rothenberg, Noyes Data Corporation, 1976
- Engineered Materials Handbook: Ceramics and glasses, ASM International. Handbook Committee ASM International, 1991 (vol. 4)

MS2080: Process Metallurgy — Credit: 1

Introduction to stoichiometry, thermochemistry, basics of materials and energy balance, applications in minerals processing.

Reading materials:

- H.S. Ray, A. Ghosh, Principles of Extractive Metallurgy, New-Age International Ltd.

MS2060: Functional and Structural Polymers — Credits: 2

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), characterization - scattering, flow in polymers- rheology, polymer blends and composites.

Reading material:

- Young, Robert J., and Peter A. Lovell. Introduction to polymers. CRC press, 2011.
- Roe, Ryong-Joon, and R. J. Roe. Methods of X-ray and neutron scattering in polymer science. Vol. 739. New York: Oxford University Press, 2000.
- White, James Lindsay. Principles of polymer engineering rheology. John Wiley and Sons, 1990.

MS2030: Materials Characterization-II — Credits: 2

X-ray diffraction and imaging: Laue diffraction, Powder diffraction, Crystal structure and size; Orientation; Phase diagram; Chemical analysis; Stress measurement, X-ray tomography. Electron diffraction and imaging: Reciprocal space; diffraction pattern; Kikuchi diffraction; Convergent beam electron diffraction; Secondary and back scatter electron imaging.

Reading materials:

- Elements of X ray diffraction, Addison-Wesley Publishing Company, Inc. (1956) by B.D. Cullity
- Applications of soft X-ray imaging to materials science, Springer 1988) by M. Shinozaki
- Physical principles of electron microscopy, Springer (2005) by Ray F. Egerton

MS2090: Electronic Materials — Credit: 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.

Reading materials:

- Introduction to solid state physics, Charles Kittel, John Wiley and sons
- Electronic properties of Materials, E.Hummel

MS2100: Rate Phenomena in Process Metallurgy — Credit: 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.)

Reading Materials

- Rate Phenomena in Process Metallurgy, Julian Szekely and Nickolas J. Themelis, Wiley Interscience, 1971
- Modeling of Steelmaking Processes, Dipak Mazumdar and James W. Evans, CRC Press, 2009

MS3010: Magnetic Materials — Credit: 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.

Reading materials:

- Introduction to solid state physics, Charles Kittel, John Wiley and sons
- Introduction to Magnetic Materials, Wiley by B.D. Cullity, C.D. Graham
- Introduction to Magnetism and Magnetic Materials – E.D Coey

MS3020: Casting and Solidification — Credits: 2

Pattern making, moulding processes and materials, core and core materials, pouring and feeding castings, solidification microstructures, ferrous and non-ferrous castings.

Reading materials:

- R.W. Heine, C.R. Loper, P.C. Rosenthal, Principles of metal castings, 2008, Tata Mcgraw-Hill, NY, USA.

MS3030: Non-Ferrous Extractive Metallurgy — Credit: 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.

Reading materials:

- Extraction of nonferrous metals, H.S. Ray, R. Sridhar and K.P. Abraham, East West Press (2007).
- The Extraction and Refining of Metals, C. Bodsworth, CRC press- 1994

MS3040: Thin Films — Credits: 2

Introduction to thin films, Formation and characterisation of thin films, 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.

Reading materials:

- Handbook of Thin Film Technology, by Leon I. Maissel and Reinhard Glang
- Materials Science of Thin Films, by Milton Ohring
- Thin Film Processes, by John L Vossen and Werner Kern

MS3050: Iron Making — Credit: 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.

Reading materials:

- A. Ghosh, A. Chatterjee, Iron making and steel making, PHI Learning (P) Ltd.
- R.H. Tupkary, V.R. Tupkary, An introduction to modern iron making, Khanna Publishers.

MS3060: Steel Making — Credit: 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.

Reading materials:

- R.H. Tupkary, An introduction to modern steelmaking, Khanna Publishers.
- A. Ghosh, A. Chatterjee, Iron making and steel making, PHI Learning (P) Ltd.

MS3070: Powder Metallurgy — Credits: 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.

Reading materials:

- An Introduction to Powder Metallurgy, F. Thummler and R. Oberacker, Money Publishing, 1994.
- Powder Metallurgy, Science and Technology and Materials, Anish Upadhyay and G. S. Upadhyay, University Press, 2011.
- ASM Handbook, Vol. 7 - Powder Metal Technologies and Applications, Edited by: ASM International Handbook Committee, ASM International, 1998.

MS3090: Phase Equilibria — Credit: 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.

Reading materials:

- David R Gaskell, “Introduction to the thermodynamics of materials”, 5th ed., Taylor and Francis, 2008

MS3100: Kinetics of Materials — Credits: 2

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.

Reading materials:

- R W Balluffi, S. Allen, W. C. Carter, "Kinetics of materials", 1st ed. MIT series Text, John Wiley and Sons, 2005

MS3110: Transport Phenomena — Credits: 2

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.

Reading materials:

- R. B. Bird, W. E. Stuart and E. N. Lightfoot, "Transport Phenomena", 2nd ed. John Wiley and Sons, 2006
- G. H. Geiger and D.R. Poirier, "Transport Phenomena in Materials Processing" TMS, 1998

MS3120: Phase Transformations — Credits: 2

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

Reading materials:

- D. A. Porter and K. E. Easterling, "Phase Transformations in Metals and Alloys", 3rd edition, CRC Press, 2009
- R W Balluffi, S. Allen, W. C. Carter, "Kinetics of materials", 1st ed. MIT series Text, John Wiley and Sons, 2005
- H. I. Aaronson ed., "Lectures on the Theory of Phase Transformations", The Minerals, Metals and Materials Society, 2001

MS3080: Computational Methods in Materials Science-II — Credits: 2

Conservation and continuity equations; Materials constitutive equations; Numerical solution - ODEs and PDEs (finite difference and finite volume methods, spectral methods); numerical implementation of random walk; mesoscale modelling- phase-field models, cellular automata, dislocation dynamics; atomistic simulations- molecular dynamics, Monte Carlo; application of quantum mechanics.

Reading materials:

- Richard LeSar, "Introduction to Computational Materials Science: Fundamentals to Applications", Cambridge University Press, 2013
- Akira Satoh, "Introduction to Practice of Molecular Simulation: Molecular Dynamics, Monte Carlo, Brownian Dynamics, Lattice Boltzmann and Dissipative Particle Dynamics", Elsevier, 2010
- 1. E. Kreyszig and E.J. Norminton, "Advanced Engineering Mathematics: Mathematica Computer Manual" 8th edition, 2001

MS3130: Non Destructive Testing — Credit: 1

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

Reading materials:

- Baldev Raj, T. Jayakumar, and M. Thavasimuthu: Practical Non-destructive Testing, Narosa Publishing House, New Delhi, 2002.
- ASM Handbook, Non-destructive evaluation and quality control, Vol.17, ASM International, Materials Park, Ohio, USA.

MS3140: Technical Communication — Credit: 1

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.

Reading materials:

- Technical Communication, Paul Anderson, Cengage Learning Publications, 2013

MS3150: Corrosion — Credit: 1

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.

Reading materials:

- Handbook of Corrosion Engineering, P. Roberge, McGraw-Hill, 1999
- Corrosion Engineering, M. G. Fontana, McGraw-Hill, 2005

MS4010: Defects in Functional Materials — Credit: 1

Types of Defects – Colour centres – optical emission – solid state lasers – Luminescence – types of luminescence – Band gap tuning – ionic conductivity – Varistors – Gas sensors - Characterization techniques of Defects – Demerits of defects – Defect induced functional failures.

Reading materials:

- Research articles
- Physics of Solids, Charles A Wert, Robb M. Thomson, McGraw-Hill Book Company

MS4020: Research Methodology — Credit: 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.

Reading materials:

- Research Methodology: A Step-by-Step Guide for Beginners, Ranjit Kumar, Sage Publications, 2010

MS4030: Materials Selection and Design — Credit: 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.

Reading materials:

- Materials and design, Butterworth-Heinemann (2009) by Michael F. Ashby and Kara Johnson
- Materials selection in mechanical design, Butterworth-Heinemann (2001) by Michael F. Ashby

MS4040: Recycling of Materials — Credit: 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.

Reading materials:

- Asmatulu, R. "Recycling of Engineering Materials – Class Notes," Wichita State University, 2008.
- Rao, S.R. "Resource Recovery and Recycling from Metallurgical Wastes," ELSEVIER, 2006.
- Lund, H.F. "Recycling Handbook, 2nd Edition," McGraw-Hill, 2000.

MS4050: Fatigue and Fracture — Credits: 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.

Reading materials:

- S. Suresh, "Fatigue of Materials", 2nd ed., Cambridge University Press, 2003
- B. R. Lawn, "Fracture of Brittle Solids", B. R. Lawn. Cambridge University Press, 1993.
- Thomas H. Courtney, "Mechanical Behaviour of Materials", Thomas H. Courtney. McGraw Hill, 1990.

MS4060: Thermo-mechanical Processing — Credits: 2

Work-hardening mechanisms, static and dynamic softening processes, processing techniques, thermo-mechanical processing of steel, aluminium, magnesium, titanium and advanced alloy systems.

Reading materials:

- H. Humphreys and M. Hatherly, Recrystallization and related annealing phenomenon, Pergamon press.
- B. Verlinden, J. Driver, I. samajdar, R.D. Doherty, Thermo-mechanical processing of metallic materials, Pergamon press.

DEPARTMENT OF MATHEMATICS

MA1110: Elements of Basic Calculus-I Credit: 1

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.

Reading Material:

- N.Piskunov, Differential and Integral Calculus, Volume I and II, Mir Publishers, Moscow.
- Thomas. G.B., and Finney, R.L., Calculus and analytic Geometry, Addison Wesley-person (India), 2007.
- Alan Jeffrey, Advanced Engineering Mathematics, Academic Press, 2002.

MA1140: Linear Algebra Credit: 1

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, Bi-linear forms, symmetric bilinear forms, skew symmetric bilinear forms.

Reading Material:

- Sheldon Axler, "Linear Algebra Done Right", University Press, 2010.
- Gilbert strang, Linear algebra and its applications, Thomson Brooks/Cole, Fourth Edition 2006.

MA1150: Differential Equations (Prerequisite(s): MA1110, MA1120, MA1140) Credit 1

Ordinary Differential Equations: First order linear equations, Bernoulli's equations, Exact equations and integrating factor, Higher order linear,differential equations with constant coefficients.

Partial Differential Equations: First order linear PDE, quasi linear PDE,method of characteristics, Cauchy problem, first order nonlinear PDE's of special type.

Reading Material:

- .Kreyszig. E. Advanced Engineering Mathematics, John Willey, 2006.
- Boyce and Di Prima, Elementary Differential Equations, Wiley, 2001.
- Ian. N. Sneddon, Elementary partial differential equations, McGrawHill Book Company,Inc., New York,1957.
- Alan Jeffrey, Advanced Engineering Mathematics, Academic Press, 2002.

MA1220: Elements of Basic Calculus-II Credits: 2

Integral Calculus: Definite Integrals as a limit of sums, Applications of integration to area, volume, surface area, Improper integrals. **Functions of several variables: C**ontinuity and differentiability, mixed partial derivatives, local maxima and minima for function of two variables, Lagrange multipliers. **Functional Series:** Pointwise and uniform convergence, basic aspects of Power series, Fourier series.

Reading Material:

- N.Piskunov, Differential and Integral Calculus, Volume I and II, Mir Publishers, Moscow.
- Kreyszig. E. Advanced Engineering Mathematics, John Willey, 2006.

MA2120: Introduction to Probability (Prerequisite(s): MA 1110) Credit: 1

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 expectance, Chebyshev inequality, functions of random variables. Special Distributions: Bernoulli, Binomial, Geometric, Pascal, Poisson, Exponential, Uniform, Normal distributions, Limit Theorems: Law of large numbers.

Reading Material:

- Oliver C.Ibe, Fundamentals of Applied Probability and Random Processes, Elsevier, 2007.
- P.L.Meyer, Introductory Probability and statistical Applications, American Publishing Company, 1990.

MA2130: Transform Techniques (Prerequisite(s): MA1110) Credit: 1

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.

Reading Material:

- E. Kreyszig, Advanced Engineering Mathematics, Addison Wiley, 1983.
- Alan Jeffrey, Advanced Engineering Mathematics, Academic press, 2003.
- I.N.Sneddon, Use of Integral Transform, McGrawHill, 1972.

MA2140: Introduction to Statistics

Random sampling, Estimation of parameters, Confidence Intervals, Testing of Hypothesis, Goodness of fit, Nonparametric tests, Correlation Analysis.

Reading Material:

- R. V Hogg and E. Tanis, "Probability and statistical inference, "Pearson Pub., 2009.
- P. G. Hoel, S. C. Port and C. J. Stone, "Introduction to probability theory, "Cengage Learning, 1972.
- Medhi, "Statistical Methods: An introductory text," New age international publishers, 2005.

MA1130: Vector Calculus (Prerequisite(s): MA1110, MA1120) Credit: 1

Double and TripleIntegrals: Calculations, Areas, Volumes, change of variables, Applications.

Integrals of Vector Functions: Line integrals, Green's formula, path independence, Surface integral: definition, evaluation, Stoke's formula, Gauss-Ostrogradsky divergence theorem.

Reading Material:

- N.Piskunov, Differential and Integral Calculus, Volume I and II, Mir Publishers, Moscow.
- Kreyszig. E. Advanced Engineering Mathematics, John Willey, 2006.
- Thomas. G.B., and Finney, R.L., Calculus and analytic Geometry, Addison Wesley-person (India), 2007.

MA2110: Introduction to Complex Variables (Prerequisite(s): MA 1110, MA 1120) Credit: 1

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.

Reading Material:

- E. Kreyszig, Advanced Engineering Mathematics, Addison Wiley, 1983.
- J.W. Brown, R.V. Churchill, Complex Variables, McGraw Hill, 8th Edition, 2010.

DEPARTMENT OF MECHANICAL ENGINEERING

ID1130: Engineering Statics (2 Credits)

Idealization in mechanics; Equilibrium of a particle and a rigid body; Types of Structures and Supports; Free - Body Diagram; Truss analysis using method of joints and sections; Statically determinate system; Force analysis in frames and machines; Internal forces; Relationship between applied load, shear force, and bending moment; Parallel-axis theorem; Polar moment of area; Radius of gyration.

References:

- F. Beer and Jr. E. R. Johnston, "Vector Mechanics for Engineers: Statics and Dynamics", 2006, McGraw Hill.
- R.C. Hibbeler and A. Gupta, "Engineering Mechanics: Statics and Dynamics", 2010, 12th Edition, Pearson Prentice Hall, New Jersey, USA.

ID1100: Fluid Mechanics-I Credits: 2

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.

References:

- Introduction to Fluid Mechanics by R. W. Fox, P. J. Pritchard and A. T. McDonald, Wiley
- Fundamental of Fluid Mechanics by B. R. Munson, A. P. Rothmayer, T. H. Okiishi and W. W. Huebsch, Wiley
- Introduction to Fluid Mechanics and Fluid Machines by S. K. Som, G. Biswas and S. Chakraborty, Tata McGraw-Hill
- Multimedia Fluid Mechanics (DVD) by G. M. Homsy et al., Cambridge University Press
- Fluid Mechanics by Frank M. White, McGraw-Hill

ID1054: Digital Fabrication Credits: 2

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.

ID1041: Engineering Drawing Credits: 2

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

References:

- Jon M. Duff and William A. Ross, "Engineering Design and Visualization", CENGAGE Learning India, India Edition, 2009.
- N. D. Bhatt, "Engineering Drawing: Plane and Solid Geometry", Charotar Publishing House, India, 2012.
- K. Venugopal, "Engineering Drawing + AutoCAD", New Age International, India, 2013.

ID1081: Fabrication Lab-I — Credits: 2

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.

References:

- A. K. Hajra Choudhury, S. K.Hajra Choudhury and Nirjhar Roy, "Elements of Workshop Technology: Vol 1 - Manufacturing Processes", Fifteenth Reprint, Media printers and publishers, India, 2012.
- A. K. Hajra Choudhury, S. K.Hajra Choudhury and Nirjhar Roy,, "Elements of Workshop Technology: Vol 2 – Machine Tools", Fifteenth Reprint, Media printers and publishers, India, 2012.
- W. A. J. Chapman, "Workshop Technology Part 2", 4th ed., Elsevier, 1972.
- A.K. Sawhney and Puneet Sawhney, "A Course in Electrical and Electronic Measurements and Instrumentation", Dhanpat Rai Publications, India, 2012.

ID1160: Solid Mechanics-I — Credits: 2

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

References:

- James M. Gere and Barry J. Goodno, "Mechanics of Materials", Cengage Learning, India, 2009.
- Ferdinand Beer, E. Russell Johnston, Jr., John DeWolf and David Mazurek, "Mechanics of Materials", 6th ed., Tata-McGraw Hill, India, 2013.
- Egor P. Popov, "Engineering Mechanics of Solids", 2nd ed., Prentice Hall, India, 2013.
- Ansel C. Ugural, "Mechanics of Materials", Wiley, 2007.
- Irving H. Shames and James M. Pitarresi, "Introduction to Solid Mechanics", 2nd ed., Prentice Hall, India, 2013

ME1020: Dynamics — Credits: 2

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.

References:

- Irving H. Shames and G. Krishna Mohana Rao, "Engineering Mechanics- Statics and Dynamics", 4th ed., Prentice Hall, India, 2006.
- R. C. Hibbeler and Ashok Gupta, "Engineering Mechanics- Statics and Dynamics", 11th ed., Prentice Hall, India, 2009.
- Ferdinand Beer, E. Russell Johnston, Jr., Phillip Cornwell and Dr. Sanghi, "Vector Mechanics for Engineers – Dynamics", 10th ed., Tata- McGraw Hill, India, 2013.
- J. L. Meriam and L. G. Kraige, "Engineering Mechanics: Volume 2 – Dynamics", 7th ed., John-Wiley, India, 2013.

ID1140: Thermodynamics-I — Credit: 1

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.

References:

- Thermodynamics: An Engineering Approach, Y. Cengel, McGraw-Hill.
- Engineering Thermodynamics by P.K. Nag, McGraw-Hill.
- Thermodynamics by J.P. Holman, McGraw-Hill.
- Thermodynamics: Concepts and Applications, Stephen R. Turns, Cambridge University Press.

ID1091: Fabrication Lab-II — Credits: 2

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.

References:

- A. K. Hajra Choudhury, S. K.Hajra Choudhury and Nirjhar Roy, "Elements of Workshop Technology: Vol 1 - Manufacturing Processes", Fifteenth Reprint, Media printers and publishers, India, 2012.
- A. K. Hajra Choudhury, S. K.Hajra Choudhury and Nirjhar Roy,, "Elements of Workshop Technology: Vol 2 – Machine Tools", Fifteenth Reprint, Media printers and publishers, India, 2012.
- W. A. J. Chapman, "Workshop Technology Part 2", 4th ed., Elsevier, 1972.
- A.K. Sawhney and Puneet Sawhney, "A Course in Electrical and Electronic Measurements and Instrumentation", Dhanpat Rai Publications, India, 2012.
- Albert P. Malvino and Jerald A. Brown, "Digital Computer Electronics", McGraw-Hill Higher Education, 3rd ed., 1992.

ID2020: Solid Mechanics-II — Credits: 2

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

References:

- James M. Gere and Barry J. Goodno, "Mechanics of Materials", Cengage Learning, India, 2009.
- Ferdinand Beer, E. Russell Johnston, Jr., John DeWolf and David Mazurek, "Mechanics of Materials", 6th ed., Tata-McGraw Hill, India, 2013.
- Egor P. Popov, "Engineering Mechanics of Solids", 2nd ed., Prentice Hall, India, 2013.
- Ansel C. Ugural, "Mechanics of Materials", Wiley, 2007.
- Irving H. Shames and James M. Pitarresi, "Introduction to Solid Mechanics", 2nd ed., Prentice Hall, India, 2013

ID1110: Fluid Mechanics-II — Credits: 1.5

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.

References:

- Fluid Mechanics by P. K. Kundu, I. M. Cohen and D. R. Dowling, Academic Press
- Introduction to Fluid Mechanics by R. W. Fox, P. J. Pritchard and A. T. McDonald, Wiley
- Fundamental of Fluid Mechanics by B. R. Munson, A. P. Rothmayer, T. H. Okiishi and W. W. Huebsch, Wiley
- Multimedia Fluid Mechanics (DVD) by G. M. Homsy et al., Cambridge University Press
- MIT-OCW, Fluid Mechanics: http://ocw.mit.edu/courses/aeronautics-and-astronautics/16-01-unified-engineering-i-ii-iii-iv-fall-2005-spring-2006/fluid-mechanics/
- NPTEL – Fluid Mechanics: http://nptel.ac.in/courses/112105171/"

ID1150: Thermodynamics-II — Credits: 2

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.

References:

- Thermodynamics: An Engineering Approach, Y. Cengel, McGraw-Hill.
- Engineering Thermodynamics, P.K. Nag, McGraw-Hill.
- Thermodynamics, J.P. Holman, McGraw-Hill.
- Thermodynamics: Concepts and Applications, Stephen R. Turns, Cambridge University Press.
- Thermodynamics and its Applications, Jefferson W. Tester and Michael Modell, Prentice Hall.
- Fundamentals of Thermodynamics, Gordon J. Van Wylen and Richard E. Sonntag, Wiley Publishers.

ME2070: Introduction to Mathematical Modelling — Credits: 1.5

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.

References:

- Getting Started with MATLAB by Rudra Pratap, Oxford University Press
- Analytical Dynamics: A New Approach, F. E. Udwadia and R. E. Kalaba, Cambrdge Univerisy Press
- Classical mechanics, H Goldstein, C. P. Poole, and J.L. Safko, Pearson

ME1010: Manufacturing Technology — Credit: 1

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.

References:

- M. P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, Third edition. Wiley India Private Limited, 2009.
- S. Kalpakjian, Manufacturing Processes for Engineering Materials, Fifth edition. Pearson Education, 2009.
- G. K. Lal and S. K. Choudhury, Fundamentals Of Manufacturing Process, 2009

ME2060: IC Engines-I — Credit: 1

Classification, Basic Working Principles, Components of an IC Engine; Engine Operating Events and Parameters: Geometry, Torque, Power and Work; Fuel Consumption and Efficiencies, Engine Cycle Models: Basic Thermodynamic Analysis; Air Standard Cycles.

References:

- Heywood, J.B., Internal Combustion Engine Fundamentals, McGraw-Hill
- Ganesan V., Internal Combustion Engines, Tata McGraw-Hill
- Stone, R., Introduction to Internal Combustion Engines, PHED

ME2040: Instrumentation — Credits: 1.5

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.

References:

- Mechanical Measurements by Thomas G. Beckwith, Roy D. Marangoni and John H. Lienhard, Pearson Prentice Hall, 2007
- Instrumentation for Engineers and Scientists, John Turner and Martyn Hill, Oxford University Press, 1999
- Theory and Design for Mechanical Measurements, Richard S. Figliola and Donald E. Beasley, John Wiley and Sons (Asia) Pte Ltd, 2008
- Measurement Systems, Ernets O Doebelin and Dhanesh N Manik, Tata McGraw-Hill, 2007

ME2030: Manufacturing Science-I — Credits: 2

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.

References:

- Ghosh and Mallick A. K., Manufacturing Science. Affiliated East-West Press Pvt. Ltd. 2010.
- M. P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, Third edition. Wiley India Private Limited, 2009.
- S. Kalpakjian, Manufacturing Processes for Engineering Materials, Fifth edition. Pearson Education, 2009.
- G. K. Lal and S. K. Choudhury, Fundamentals Of Manufacturing Process, 2009. Boca Raton, FL: CRC Press, 2011.
- J.P.Holman, Experimental Methods for Engineers, McGraw Hills Int. Edition.
- R.K.Jain, Engineering Metrology, Khanna Publishers, 2013.

ME2220: Kinematics and Dynamics of Machinery — Credits: 4

Basic kinematic concepts, introduction to mechanisms, links, kinematic pairs, kinematic chains, mechanism and inversions, Kennedy's theorem, velocity and acceleration in mechanism, relative velocity methods, instantaneous center of rotation, acceleration diagram, synthesis of planar mechanisms. Cams: synthesis of translating flat-face, translating roller and oscillating roller follower cams. gears: terminology, fundamental law of gearing, involute profile, interference and undercutting, minimum number of teeth, contact ratio, bevel helical, spiral and worm gears, gear trains – simple, compound and epicyclic gear trains; sliding gear boxes and synchronous gear boxes. dynamics of machines: dynamics of rigid bodies in plane motion; dynamic force analysis of machines. Flywheels, balancing of rotors and in-line internal combustion engines, Chain and belt drive.

References:

- R L Norton "Kinematics and Dynamics of Machinery" McGraw- Hill companies, 2009
- Kenneth J. Waldron and Gary L. Kinzel, "Kinematics, Dynamics and Design of Machinery", Wiley India Edition
- Amitabha Ghosh, Ashok Kumar Malik, "Theory of Mechanisms and Machines", East-West Press Private Limited, New Delhi, 2004.
- John J. Uicker, Gordon R. Pennock, Joseph E. Shigley, "Theory of Machines and Mechanisms", Oxford University Press, New Delhi, 2009.
- S. S. Rattan, "Theory of Machines", Tata-McGraw Hill Eductaion Private Ltd, New Delhi, 2009. 6. David H. Myszka, "Machines and Mechanisms", Prentice-Hall Inc (PHI) Learning Private Limited, New Delhi, 2009.

ME2421: Solid Mechanics Lab — Credits: 1

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

ME2431: Fluid Mechanics Lab — Credit: 1

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: Manufacturing Science-II — Credits: 2

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.

References:

- Ghosh and Mallick A. K., Manufacturing Science. Affiliated East-West Press Pvt. Ltd. 2010.
- M. P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, Third edition. Wiley India Private Limited, 2009.
- S. Kalpakjian, Manufacturing Processes for Engineering Materials, Fifth edition. Pearson Education, 2009.
- G. K. Lal and S. K. Choudhury, Fundamentals Of Manufacturing Process, 2009
- M. J. Madou, Fundamentals of Microfabrication and Nanotechnology, 3rd Edition, CRC Press, 2011.

ME3020: IC Engines-II — Credits: 2

Thermochemistry for IC Engines: Fuels and Testing; Combustion Reactions; Combustion Efficiencies; Chemical Kinetics and Exhaust Gas Analysis, Engine Cycle Models: 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, New Combustion Concepts in IC Engines - Gasoline Direct Injection, Homogeneous Charge Compression Ignition, Dual Fuel Ignition, Renewable Fuels for IC Engines.

References:

- Heywood, J.B., Internal Combustion Engine Fundamentals, McGraw-Hill
- Ganesan V., Internal Combustion Engines, Tata McGraw-Hill
- Stone, R., Introduction to Internal Combustion Engines, PHED
- Taylor, C.F., Internal Combustion Engine in Theory and Practice, Vol 1 and 2, MIT Press
- Baumgarten, C., Mixture Formation in Internal Combustion Engines, Springer Berlin Heidelberg
- Hiereth, H., Prenninger, P., Drexl, K., Charging The Internal Combustion Engine, Springer

ME3130: Design of Machine Elements — Credits: 4

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

References:

- Norton, "Machine Design", Pearson.
- Shigley, "Mechanical Engineering Design", McGraw-Hill.
- V. B. Bhandari, "Design of Machine Elements," Tata McGraw-Hill.

ME3110: Heat and Mass Transfer — Credits: 3

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.

References:

- Fundamentals of Heat and Mass transfer, Frank P Incropera and David P Dewitt, Wiley – India edition, 5th edition-2009.
- Heat transfer, J. P. Holman, Tata-Mc-Graw Hill, New Delhi, 9th edition- 2009.
- Heat and Mass transfer - A Practical approach, Yunus A Cengel, Tata-Mc-Graw Hill education private Limited, New Delhi, 2009.
- Process Heat Transfer, Donald Q. Kern, McGraw-Hill.

ME3445: Finite Element Methods Lab — Credit: 1

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).

References:

- ANSYS/ABAQUS Documentation

ME3030: Modeling and Simulation — Credits: 3

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

References:

- Getting Started with MATLAB by Rudra Pratap, Oxford University Press
- Analytical Dynamics: A New Approach, F. E. Udwadia and R. E. Kalaba, Cambridge University Press
- Classical mechanics, H Goldstein, C. P. Poole, and J.L. Safko, Pearson

ME3040: Mathematical Elements for Geometrical Modeling — Credits: 1.5

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.

References:

- Groover, M. CAD/CAM. First edition. Delhi: Pearson Education, 2003.
- Lee, Kunwoo. Principles of CAD/CAM/CAE. 1 edition. Reading, Mass: Prentice Hall, 1999.
- Rao, P. N. CAD/CAM: Principles and Applications. 3 edition. New Delhi: Mcgraw-Hill Education, 2010.
- Zeid, Ibrahim, and R. Sivasubramanian. CAD/CAM: THEORY and PRACTICE: Special Indian Edition. 2 edition. New Delhi: Tata McGraw Hill Education, 2009.

ME3050: Computer Integrated Manufacturing — Credits: 1.5

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.

References:

- Groover, M. CAD/CAM. First edition. Delhi: Pearson Education, 2003.
- Lee, Kunwoo. Principles of CAD/CAM/CAE. 1 edition. Reading, Mass: Prentice Hall, 1999.
- Rao, P. N. CAD/CAM: Principles and Applications. 3 edition. New Delhi: Mcgraw-Hill Education, 2010.
- Zeid, Ibrahim, and R. Sivasubramanian. CAD/CAM: THEORY and PRACTICE: Special Indian Edition. 2 edition. New Delhi: Tata McGraw Hill Education, 2009.

ME3060: Experimental Testing Techniques — Credit: 1

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.

References:

- Kiemele, Mark J. Basic Statistics: Tools for Continuous Improvement. 4 edition. Colorado Springs, Colo.: Air Academy Press, 1997.
- Holman, J. P., Experimental Methods for Engineers, Mc-Graw Hill, 7th Ed, Singapore, 2001.
- Montgomery, Douglas C. Design and Analysis of Experiments: International Student Version. Eighth edition. Wiley India Private Limited, 2013.
- E.O.Doeblin, Engineering Experimentation, McGraw Hills Int. Edition.

ME3413: Machine Drawing and Solid Modelling — Credits: 2

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.

References:

- K. L. Narayana, P. Kannaiah, K. Venkata Reddy, Machine Drawing, New Age International, 2010.
- N. D. Junnarkar, Machine DrawingPearson Education India, 2007.
- Engine model resources: http://grabcad.com/

ME3425: Mini-project — Credits: 3

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.

ME3465: Manufacturing Lab — Credit: 1

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: IC Engines Lab — Credit: 1

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.

References:

- VCR Engine manual that includes experimental procedures to follow, specifications of various equipments, and theoretical calculation procedures and formulae.
- Internal Combustion Engine fundamentals, J.B. Haywood, McGraw-Hill.

ME4010: Control Systems — Credits: 1.5

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.

References:

1. K. Ogata, Modern Control Engineering, Prentice Hall.
2. Farid Golnaraghi, and Benjamin C. Kuo, Automatic Control Systems, Wiley.
3. Goodwin, Graebe, and Salgado, Control System Design, Prentice Hall.

ME4020: Turbo Machines — Credits: 3

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.

References:

- Dixon, S.L., Hall, C.A., Fluid Mechanics and Thermodynamics of Turbomachinery, Elsevier
- Turton, R.K., Principles of Turbomachinery, Chapman and Hall

ME4030: Operations Research — Credit: 1

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).

References:

- Eric. V. Denardo, "The Science of Decision Making: A Problem based approach using Excel", John Wiley and Sons
- MIT OpenCourseware 2.854/2.853 Introduction to Manufacturing Systems http://ocw.mit.edu/courses/mechanical-engineering/2-854-introduction-to-manufacturing-systems-fall-2010/index.htm

ME4040: Industrial Engineering — Credit: 1

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.

References:

- R. Dan Reid, Nada R. Sanders, "Operations Management - An Integrated Approach", 5th Edition, Wiley Publications 2010
- S. N. Chary, "Production and Operations Management",3rd Edition, Tata McGraw Hill Publishers, 2004

ME4050: Production Planning and Control — Credit: 1

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.

References:

- R. Dan Reid, Nada R. Sanders, "Operations Management - An Integrated Approach", 5th Edition, Wiley Publications 2010
- David Simchi-Levi, Philip Kaminsky, Edith Simchi-Levi, Ravi Shankar, " Designing and Managing the Supply Chain – Concepts, Strategies and Case Studies", 3rd Edition (Special Indian Edition), McGraw Hill Education, 2008
- MIT OpenCourseWare 2.830J/ 6.780J / ESD.63J Control of Manufacturing Processes (SMA 6303) http://ocw.mit.edu/courses/mechanical-engineering/2-830j-control-of-manufacturing-processes-sma-6303-spring-2008/

ME4435: Dynamics lab — Credit: 1

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: Heat Transfer lab — Credit: 1

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.

References:

1. Fundamentals of Heat and Mass transfer, Frank P Incropera and David P Dewitt, Wiley – India edition, 5th edition-2009.
2. Heat transfer, J. P. Holman, Tata-Mc-Graw Hill, New Delhi, 9th edition- 2009.

ME5020: Elasticity and Plasticity — Credits: 1.5

Elastic and Plastic Behaviour of Metals; Stress: Introduction, Invariants, Deviatoric stress and equilibrium equations; Strain: Introduction, Compatibility, Strain Invariants and Deviatoric Tensor; Stress and Strain Relations (Elastic and Plastic); Yield and Flow: Yield Condition, Isotropic Yield Criteria (von-Mises, Tresca and Hill), Experimental Verification of Yield Criteria, Anisotropy and Anisotropic Yield Criteria.

References:

- Elasticity: Theory, Applications and Numerics,"" Second Edition, by M. H. Sadd, Elsevier, 2009 2. S A Khan and S Huang, Continuum Theory of Plasticity, John Wiley, 1995 3. Dixit and Dixit, Modelling of Metal Forming and Machining Processes, Springer, 2008 4. G K Lal and Reddy N V, Introduction to Engineering Plasticity, Narosa, 2009.

ME5030: Fluid Mechanics and Heat Transfer — Credits: 1.5

Introduction to Fluid flow; Lagrangian and Euler frames of reference; Material derivative; streamlines, streamlines and path lines; velocity potential and stream function; Conservation of mass and momentum; continuity equation; potential flows; Elliptic equations; boundary conditions; Euler equations; Newton's law of viscosity; Navier-Stokes equations; boundary conditions; Boundary layers; Turbulence; Turbulence modelling; Heat conduction; transient and steady heat conduction equation; Natural convection; Forced Convection; Non-dimensionalization, and non-dimensional parameters; Turbulent convection

References:

- Fluid Mechanics by P. K. Kundu, I. M. Cohen and D. R. Dowling, Academic Press
- Viscous Fluid Flow by Frank M. White, McGraw-Hill
- Introduction to Fluid Mechanics and Fluid Machines by S. K. Som, G. Biswas and S. Chakraborty, Tata McGraw-Hill
- Introduction to Fluid Mechanics by James A. Fay, MIT Press
- Fundamentals of Heat and Mass Transfer, T. L. Bergman, A. S. Lavine, F. P. Incropera, D. P. DeWitt, Wiley
- Heat and Mass Transfer: Fundamentals and Applications, Y. Cengel and A. Ghajar, McGraw-Hill
- NPTEL – Fluid Mechanics: http://nptel.ac.in/courses/112105171/
- NPTEL – Heat and Mass Transfer: http://nptel.ac.in/courses/112101097/

ME5040: Computational Fluid Dynamics Tools — Credits: 1.5

Introduction to Navier Stokes equation, basics of discretization methods, finite volume formulation of convection-diffusion equation, pressure-velocity coupling, boundary condition implementation, mesh generation techniques in CFD, CFD applications in manufacturing processes through examples - heat removal during machining process, laser welding process, casting, spray coating process

References:

- Patankar, S.V., Numerical Heat Transfer, Taylor and Francis
- Versteeg, H.K., Malalasekera, W., An Introduction to Computational Fluid Dynamics - The Finite Volume Method, Longman
- Tannehill, J.C., Anderson, D.A., Pletcher, R.H., Computational Fluid Mechanics and Heat Transfer, Taylor and Francis

ME5421: FEM Lab — Credit: 1

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).

ME5050: Material Science and Material Selection — Credits: 1.5

Phase and Phase diagrams, Diffusion in Solids, Fundamentals of dislocations and strengthening mechanisms, Mechanical behavior of materials. Materials and design, Evolution of Engineering Materials and their Properties, Materials selection charts, Selection of Engineering materials and their Shape, Selection of Manufacturing Processes, Examples and Case studies.

References:

- G E Dieter, Mechanical Metallurgy, McGrawHill, YEAR
- M F Ashby and K Johnson, Materials and Design, Butterworth-Heinemann, 2014
- M F Ashby, Materials Selection in Mechanical Design, 4th Edition, Butterworth-Heinemann, 2010
- K G Swift, Process Selection from Design to Manufacture, Butterworth-Heinemann, 2003.

ME5060: Manufacturing Processes — Credits: 2

Classification, operating parameters, and throughputs of manufacturing processes – Generative, Additive, and Removal Processes; Conventional and Non-conventional process; Contact and Non-contact processes; Hybrid manufacturing processes. Characterization of manufactured products: Form and Surface features, Residual stress, Mechanical properties, Corrosion resistance; Process control and feedback: Electrical, hydraulic, pneumatic, and optical sensors; open and closed loop control.

References:

- Principles of metal manufacturing processes by Jonathan Beddoes and M. J Bibby, Elsevier, ISBN 8131201333, 9788131201336
- Manufacturing Processes for Design Professionals by Rob Thompson, Publisher: Thames and Hudson, ISBN-10: 0500513759, ISBN-13: 978-0500513750
- Manufacturing Science by Amitabha Ghosh and Asok Kumar Malik, Publisher: Affiliated East-West Press Pvt. Ltd. ISBN-10: 8176710636, ISBN-13: 978-8176710633.

ME5070: Design for Manufacturability and Assembly — Credit: 1

Introduction to design for manufacturing concepts; importance of product specification and standardization, selection of materials and shapes, design rules for various manufacturing processes, design for assembly, design for reassembly, design for automated assembly, design for ergonomics, design for quality and reliability, design for X concepts.

References:

- Ashby. Materials Selection in Mechanical Design. Fourth edition. Elsevier, 2011
- Boothroyd, Geoffrey, Peter Dewhurst, and Winston A. Knight. Product Design for Manufacture and Assembly, 3rd edition, Fl: Standards media, 2010
- Swift, K. G., and J. D. Booker. Manufacturing Process Selection Handbook, Butterworth-Heinemann, 2013.

ME5080: Scaling Laws and Multi-scale Manufacture — Credit: 1

Introduction to Macro and micro-manufacturing, Importance of Scaling Laws. Scaling Laws in Mechanics, fluids, thermodynamics, Electromagnetism, tribology and Examples. Trimmer force scaling vector. Micro-Fabrication – Fundamentals of Micro-fabrication and Materials, Micro Manufacturing Processes (Additive, Formative and Removal) and their scientific and technological details, Applications. Sensing (measurement) and Control.

References:

- Y Qin, Macro Manufacturing Engineering and Technology, Elsevier, 2010
- Mark Madou, Fundamentals of Microfabrication and Nano Technology, CRC Press, 2011

ME5090: Mathematical Elements for Geometrical Modeling — Credits: 1.5

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.

References:

- Groover, M. CAD/CAM. First edition. Delhi: Pearson Education, 2003.
- Lee, Kunwoo. Principles of CAD/CAM/CAE. 1 edition. Reading, Mass: Prentice Hall, 1999.
- Rao, P. N. CAD/CAM: Principles and Applications. 3 edition. New Delhi: Mcgraw-Hill Education, 2010.
- Zeid, Ibrahim, and R. Sivasubramanian. CAD/CAM: THEORY and PRACTICE: Special Indian Edition. 2 edition. New Delhi: Tata McGraw Hill Education, 2009.

ME5100: Computer Integrated Manufacturing — Credits: 1.5

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.

References:

- Groover, M. CAD/CAM. First edition. Delhi: Pearson Education, 2003.
- Lee, Kunwoo. Principles of CAD/CAM/CAE. 1 edition. Reading, Mass: Prentice Hall, 1999.
- Rao, P. N. CAD/CAM: Principles and Applications. 3 edition. New Delhi: Mcgraw-Hill Education, 2010.
- Zeid, Ibrahim, and R. Sivasubramanian. CAD/CAM: THEORY and PRACTICE: Special Indian Edition. 2 edition. New Delhi: Tata McGraw Hill Education, 2009.

ME5140: Process Control and Optimization — Credits: 1.5

Introduction to Processes and Variation, Probability Models of Manufacturing Processes, Statistical modeling and control in manufacturing processes, Sampling Distributions and Statistical Hypotheses, Statistical Process Control. Design of Experiments, ANOVA. Use of experimental design and response surface modeling to understand manufacturing processes. Multi criteria optimization. Case studies.

References:

- Montgomery, Douglas C. Introduction to Statistical Quality Control. 5th ed. New York, NY: Wiley, 2004. ISBN: 9780471656319.
- Kiemele, Mark J. Basic Statistics: Tools for Continuous Improvement. 4 edition. Colorado Springs, Colo.: Air Academy Press, 1997.

ME5150: Computational Intelligence — Credits: 1.5

Function approximation and Pattern recognition: Statistical modelling, Neural Network, Fuzzy system and Classification, Principal Component Analysis; Evolutionary computation: Genetic algorithms; Meta-heuristic methods: Simulated annealing, Ant colony optimization, Tabu search; Monte-Carlo simulation, Design and analysis of experiments.

References:

- Foundations of neural networks, fuzzy systems, and knowledge engineering by Nikola K. Kasabov. Publisher: Cambridge, Mass.: MIT Press. ISBN 0585038767, ISBN 9780585038766; ISBN9781613448212
- Computational intelligence in manufacturing handbook by Andrew Kusiak and Publishers: CRC Press, ISBN 0849305926
- Computational intelligence in design and manufacturing by Andrew Kusiak, Publisher: New York: John Wiley and Sons, ISBN 0471348791
- Montgomery, Douglas C. Design and Analysis of Experiments: International Student Version. Eighth edition. Wiley India Private Limited, 2013.

ME5160: Material Removal Processes — Credits: 3

Conventional and non-conventional machining operation; Machine tools; Cutting Tool: Tool material, Tool geometry, Tool wear; Metal working fluids; Machinability. Mechanics of Machining Operation, Dynamometry in machining operations. Surface Integrity; Precision machining; Machining Economics; Environmentally friendly machining, Machining of difficult to cut materials.

References:

- Metal Machining: Theory and Applications by K. Maekawa, T. Obikawa, Y. Yamane, T.H.C. Childs. Publisher: Butterworth-Heinemann. ISBN-10: 034069159X, ISBN-13: 978-0340691595
- Manufacturing Processes 1 - Cutting by Fritz Klocke, Publisher: Springer ISBN: 978-3-642-11978-1, 978-3-642-11979-8
- Applied Machining Technology by Heinz Tschätsch, Publisher: Springer, ISBN: 978-3-642-01006-4, 978-3-642-01007-1
- Metal Cutting by E. M. Trent and Paul K. wright, Publishers: Butterworths, London. ISBN 10: 0408108568 / ISBN 13: 9780408108560

ME5170: Welding and Joining — Credits: 3

Modern welding process: GMAW (Robotic, CMT, and STT), Micro plasma welding, EBW, LBW, Diffusion bonding, Ultrasonic welding, Pulsed current welding, Friction stir welding, Magnetic Pulse welding. Analysis of heat sources for material joining, 2D and 3D heat flow in welds, Residual stress analysis, Arc physics. Parameters in welding and their control, Pre and post weld heat treatment. Welding of Steels, Aluminum alloys, Ceramics, Plastics, Composites, Welding of dissimilar materials; Weldment design for static and fatigue loading, Failure of welds, NDT of welds, Inspection codes, Welding symbols; Welding of pressure vessels, offshore structures and submarine pipelines, heavy structures.

References:

- Principles of Welding: Processes, Physics, Chemistry, and Metallurgy by Robert W. Messler Jr. Publisher: New York: John Wiley, ISBN 0471253766, 9780471253761
- The Physics of Welding by J. F Lancaster. Publisher: Oxford, Pergamon. ISBN0080340768, 9780080340760
- Computational Welding Mechanics by John A. Goldak and Mehdi Akhlaghi. Publisher: Springer, ISBN 0387232877, 9780387232874
- ASM Handbook, V. 6. Welding, Brazing, and Soldering. ISBN 0-87170-377-7

ME5180: Metal Forming Processes — Credits: 3

Plasticity - Yield and Flow: Yield Condition, Yield Criteria(Isotropic and Anisotropic), Plastic Instability; Slip-line Field Theory; Limit Analysis: Lower and Upper Bound Techniques, Metal Forming- Bulk Processes: Rolling, Extrusion, Drawing and Forging (Each Process will be analysed using Force Equilibrium, Slip-line and Upper Bound Methods), Tool Design, Defects and Remedies; Sheet Metal Forming: Shearing, Bending, Deep Drawing (all its variants) and other processes; Hydro Forming, Explosive Forming, Electro-Magnetic Forming, Electro-Plasticity. Scaling laws in Plasticity and Micro-Forming; Analysis of Forming Processes including defects using Finite Element Analysis.

References:

- S A Khan and S Huang, Continuum Theory of Plasticity, John Wiley, 1995 W Hosford, The Mechanics of Crystals and Textured Polycrystals, Oxford, 1993.
- Dixit and Dixit, Modelling of Metal Forming and Machining Processes, Springer, 2008
- D Banabic, Sheet Metal Forming Processes: Constitutive Modelling and Numerical Simulation, Springer 2010
- G K Lal and Reddy N V, Introduction to Engineering Plasticity, Narosa, 2009. Frank Vollertsen (Ed.) Micro Metal Forming Springer 2013.

ME5431: Integrated Design and Manufacturing Lab — Credits: 2

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. Lab project

DEPARTMENT OF PHYSICS

PH1017: Classical Physics — Credit: 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.

Reading Material:

- Classical Mechanics by Goldstein
- Classical Mechanics and Relativity by Harald JW Mullar Kirsten
- Classical Mechanics by Rana and Joag

PH1027: Maxwell's Equations and Electromagnetic Waves — Credit: 1

Maxwell's equations in matter, Boundary conditions, Poynting's theorem, Newton's third law in Electrodynamics, Maxwell's stress tensor, Conservation of Momentum, Electromagnetic waves in vacuum, and matter, absorption and dispersion, Guided waves.

Reading Material:

- Introduction to Electrodynamics, 3rd Edition, by David J. Griffiths.
- Classical Electrodynamics by John David Jackson

PH5247/PH3317: Thermal Physics — Credit: 1

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.

Reading Material:

- H B Callen, "Thermodynamics and an introduction to Themostatistics"
- Mehran Kardar, "Statistical Physics of Particles"

PH2017: Relativity — Credit: 1

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, Lorentz group, equivalence principle and general theory of relativity.

Reading Material:

- Concept of Modern Physics by A. Beiser.
- Introduction to Electrodynamics by J.D. Griffiths

PH2117: Photonics — Credit: 1

Photonics and light technology, Properties of photons, Geometrical Optics, Ray Matrices.

Reading Material:

- Photonics by Menzel
- Optics by Hecht and Ganesan

PH2027: Quantum Physics — Credit: 1

Classical to quantum cross-over, basic principles of quantum mechanics, wave function and uncertainty principle, Schrodinger formalism, time-independent and time-dependent Schrodinger equations, Dirac formulation of quantum mechanics, completeness and orthonormalization of basis vectors, basis sets, eigenstate and eigenvalues.

Reading Material:

- Quantum Mechanics by Stephen Gasiorowicz
- Principles of Quantum Mechanics by R. Shankar

PH5127/PH3127: Hydrogenic Atom — Credit: 1

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.

Reading Material:

- Quantum Mechanics Stephen Gasiorowicz
- Principles of Quantum Mechanics by R. Shankar

PH5137/PH3237: Approximation Methods in Quantum Mechanics — Credit: 1

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.

Reading Material:

- Quantum Mechanic by Stephen Gasiorowicz
- Principles of Quantum Mechanics by R. Shankar

PH5197/PH2197: Complex Analysis — Credit: 1

Analytic functions, Cauchy theorem, Cauchy's integral representations, Taylor and Laurent series, Calculus of residues, Analytic continuation, conformal mapping.

Reading Material:

- Arfken and Weber; Mathematical methods for Physicists; Academic Press

PH5177/PH2177: Linear Vector Spaces — Credit: 1

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.

Reading Material:

- P. Dennery and A. Krzywicki; Mathematics for Physicists; Dover Publications

PH5187/PH2187: Fourier Series and Integral Transforms — Credit: 1

Fourier series, Fourier transforms, Convolution theorem, Laplace transforms, Applications of Fourier and laplace transforms.

Reading Material:

- Arfken and Weber; Mathematical methods for Physicists; Academic Press

PH5227/PH3227: Nonlinear Dynamics — Credit: 1

Nonlinear methods and chaos, stability, logistic map, nonlinear differential equations.

Reading Material:

- Stogatz, "Non-linear dynamics and Chaos"

PH5167/PH3367: Experimental Techniques — Credit: 1

Vacuum Techniques, Charged Particle Optics, Data Analysis, Error Analysis.

Reading Material:

- The Laboratory Companion by Gary Coyne
- Building Scientific Apparatus by Moore, Davis, Coplan and Greer
- Introduction to Error Analysis, J. R Taylor

PH5117/PH3117: Wave Formalism of Quantum Mechanics — Credit: 1

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 an infinite potential box, square well potential and tunnelling, linear harmonic oscillator.

Reading Material:

- Quantum Mechanics by Stephen Gasiorowicz
- Principles of Quantum Mechanics by R. Shankar

PH6288/PH3288: Analytical Mechanics — Credits: 2

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.

Reading Material:

- Rana and Joag, "Classical Mechanics"
- Goldstein, "Classical Mechanics"

PH5287/PH2287: Special Functions and Differential Equations — Credit: 1

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.

Reading Material:

- Arfken and Weber; Mathematical methods for Physicists; Academic Press
- J. D. Jackson; Classical Electrodynamics

PH6248/PH3348: Statistical Physics — Credits: 2

Liouville's theorem, ensembles: microcanonical, canonical and grand canonical; mixing entropy and Gibb's paradox, equilibrium distributions, partition functions, Quantum statistical mechanics.

Reading Material:

- Mehran Kardar, "Statistical Physics of Particles",
- S K Ma, "Statistical Mechanics",
- Landau and Lifshitz, "Statistical Physics - Part 1"

PH6238/PH3338: Photonics and Laser — Credits: 2

Linear Interaction between Light and Matter, Non-linear Interaction between Light and Matter without absorption, Non-linear Interaction between Light and Matter with absorption, Basic laser theory, Lasers and its classification.

Reading Material:

- Optics by Hecht and Ganesan
- Lasers by Thyagrajan and Ghatak

PH5347/PH3347: Crystal Structure — Credit: 1

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.

Reading Material:

- C. Kittel, Introduction to Solid State Physics, 8th Edition, (Wiley, 2004)
- N. W. Ashcroft and N.D. Mermin, Solid State Physics, (Holt, Rinehart and Winston, 1976).

PH5337/PH3337: High Energy Physics — Credit: 1

Basic constituents of matter, Forces in nature, Accelerators: Cosmic and Manmade, Detectors, Exotic Matter.

Reading Material:

- D. H. Perkins, Introduction to High Energy Physics, Oxford Univ. Press

PH5257/PH3287: Atomic-Molecular Physics — Credit: 1

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.

Reading Material:

- Physics of atoms and molecules by Brensden and Joachain
- Atomic and molecular spectroscopy by Svanberg

PH55157/PH3257: Numerical Methods — Credit: 1

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.

Reading Material:

- Advanced Engineering Mathematics by Erwin Kreyzig
- R W Hamming, Numerical methods for Scientists and Engineers, Dover Publications

PH5267/PH3267: Symmetries in Quantum Mechanics — Credit: 1

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.

Reading Material:

- Quantum Mechanics by Stephen Gasiorowicz
- Principles of Quantum Mechanics by R. Shankar

PH5277/PH3277: Relativistic Quantum Mechanics — Credit: 1

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.

Reading Material:

- Advanced Quantum Mechanics by J.J. Sakurai

PH5297/PH2297: Group Theory — Credit: 1

Class, Cosets, Factor group, Character table, Reducible and Irreducible representations, Lie gropups, Applications of group theory in Physics.

Reading Material:

- J. F. Cornwell; Group theory in Physics; Academic Press

PH6218/PH2218: Electrodynamics — Credits: 2

Electromotive force, Electromagnetic induction, Maxwell's equations, conservation laws, Poynting theorem, Maxwell's stress tensor, conservation of momentum, Electromagnetic waves, Electromagnetic waves in vacuum and matter, Absorption and Dispersion, Wave Guides, Potentials and fields, Gauge transformations, Dipole radiation, Power radiated by point charge.

Reading Material:

- Introduction to Electrodynamics, 3rd Edition, by David J. Griffiths.
- Classical Electrodynamics : John David Jackson

PH6268/PH4268: Solid State Physics — Credits: 2

Crystalline Solids, Free electron gas in 3D, Introduction to Band theory of solids, Lattice Vibrations-Mono atomic and di-atomic lattices, Phonon frequencies and density of states, Thermal expansion and thermal conductivity, Magnetic properties of solids.

Reading Material:

- C. Kittel, Introduction to Solid State Physics, 8th Edition, (Wiley, 2004).
- J. Dekker, Solid State Physics, (MacMillan)

PH6278/PH3478: Particle Physics — Credits: 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, 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.

Reading Material:

- F. Halzen and A. Martin, Quarks and Leptons, John Wiley
- R. Phillips and V Barger, Collider Physics, Frontiers in Physics, AP

PH6327/PH3537: Nuclear Physics — Credit: 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.

Reading Material:

- K. S. Krane, Introductory Nuclear Physics, John Wiley and Sons

PH6258/PH3358: Spectroscopy — Credits: 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.

Reading Material:

- Physics of atoms and molecules by Brensden and Joachain
- Atomic and molecular spectroscopy by Svanberg

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