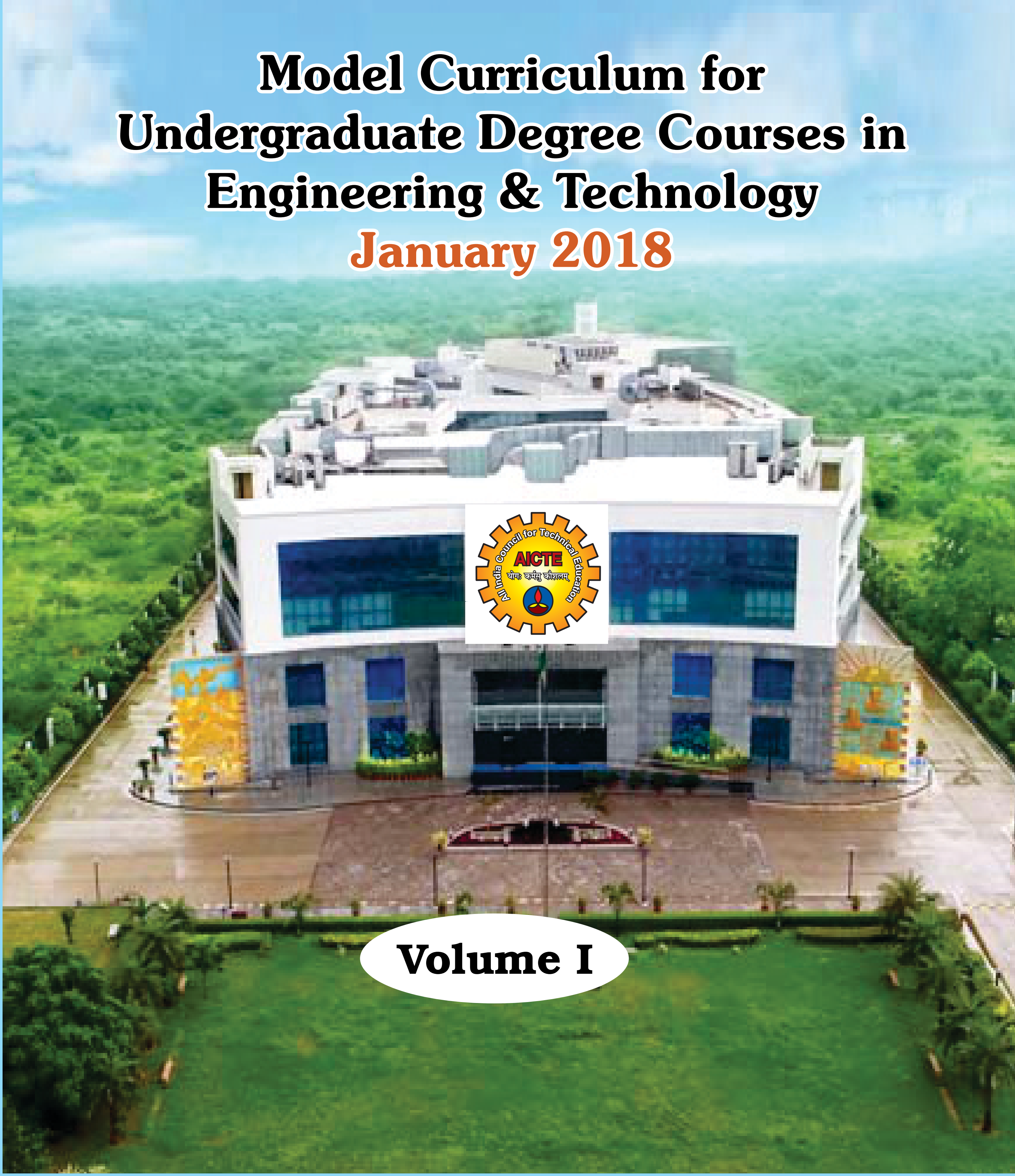
Model Curriculum for Undergraduate Degree Courses in Engineering & Technology

January 2018



Volume I

ALL INDIA COUNCIL FOR TECHNICAL EDUCATION
Nelson Mandela Marg, Vasant Kunj, New Delhi 110070
www.aicte-india.org

MODEL CURRICULUM FOR UNDERGRADUATE DEGREE COURSES IN ENGINEERING & TECHNOLOGY

January 2018

(Volume I)

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Nelson Mandela Marg, Vasant Kunj, New Delhi 110 070
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सत्यमेव जयते
Government of India
Ministry of Human Resource
Development

Prakash Javadekar
Minister of Human Resource Development
Government of India

Message

India is a diverse economy and students of today will be the young leaders of tomorrow. India is renowned in producing students of high calibre and it is necessary that our aspiring students are able to pursue the right education. As we are all aware that engineering education is gaining new heights and contributes a substantial share in the overall education system, the youngsters pursuing engineering studies need to be well equipped and updated with the latest technological trends and industrial requirements. This is possible only when the students undergo studies with an updated and evolving curriculum to match global scenario.

I congratulate AICTE for developing a model curriculum with the help of academic and industry experts for various disciplines of Undergraduate Degree courses in Engineering & Technology which will be available for Universities and Institutions. This adoption will be advantageous for the students to enhance their skills and employability. Introduction of mandatory Induction program for students belonging to diverse backgrounds to adjust themselves in the new environment of Engineering degree courses is praise worthy.

An initiative to be continued in future as well….

(Prakash Javadekar)

सत्यमेव जयते

स्वच्छ भारत
एक कदम स्वच्छता की ओर

सूचना का अधिकार

R. SUBRAHMANYAM, IAS
Special Secretary

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मानव संसाधन विकास मंत्रालय
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MINISTRY OF HUMAN RESOURCE DEVELOPMENT
DEPARTMENT OF HIGHER EDUCATION
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Message

The economic progress of a country is strongly linked to the quality of technical education in the country. In order to sustain the growth rates of the economy, the pool of technical talent needs to continue to grow. Our country has witnessed a significant increase in the number of engineering graduates coming out of the technical institutions. Notwithstanding that the quality of technical education has to be continuously enriched with implementation of various quality initiatives. Education is a very dynamic field and talking about our engineering graduates, in particular, have to be educated and trained keeping in view the employability and self-sustaining factor viz. start-ups. A revision of engineering curriculum was a need of the hour and AICTE has developed latest Model curriculum for various undergraduate degree engineering disciplines. Kudos to AICTE and the Committees and teams who have immensely contributed and prepared a model curriculum for the benefit of the institution, the faculty and engineering students who are the key beneficiaries.

Revision of curriculum is not a stand-alone measure for bringing in reforms in technical education and will also be supported by various other initiatives. A need for industry-institute interaction and internship of students in an industry will definitely help students to learn and develop good communications skills and team work management. An appreciation of the fact that induction program for students and other mandatory non-credit courses along with an internship for students are a part of this curriculum. I hope that AICTE will ensure the revision of this model curriculum on regular basis and this updation will certainly help students achieve better employability; start-ups and other avenues for higher studies.

R. SUBRAHMANYAM

शिक्षा का अधिकार
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सब पढ़ें सब बढ़ें

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(Ministry of Human Resource Development, Govt. of India)
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Message

The quality of technical education depends on various factors ; outcome based socially and industrially relevant curriculum, good quality motivated faculty, teaching learning process, industry internships, evaluation of students based on desired outcomes among others. In engineering education, IITs have been a sterling example not only in India but have become a global brand. Therefore, it was of imperative that a revised AICTE model curriculum be prepared by best faculty drawn from IITs, keeping in view the latest industry trends and market requirements in all major engineering subjects and be made available to all universities and engineering institutions in the country. With the support of Ministry of Human Resource Development, AICTE constituted subject-wise heads of the committees from IITs with respective team of 2-3 academic experts along with industry expert to revise the model curriculum of undergraduate engineering courses. Similar exercise is done for programmes at Diploma and PG level in engineering, MBA, PGDM, Pharmacy, Architecture, etc.

The revised model UG curriculum in engineering has been designed where number of credits have been reduced to 160 credits with a core comprising basic sciences and engineering having focus on fundamentals, discipline level significant courses and ample opportunity for the students to take electives both from the discipline and cross disciplines, provision for internship to understand the industry requirements, have hands-on experience and to pursue project work in their final year relevant to industry. This will allow the students to develop a problem solving approach to meet the challenges in future. As a major initiative by AICTE, a three week mandatory induction program for students has also been designed to be offered right at the commencement of the first year and classes will begin after this induction program. Its purpose is to make the students feel comfortable in their new environment, open them up, set a healthy daily routine, create bonding in the batch as well as between faculty and students, develop awareness, sensitivity and understanding of the self, people around them, society at large, and nature.

The heads of the committee along with their teams have prepared the model curriculum for respective engineering disciplines. It is with great pleasure we thank each Head of the Committee along with their team of academic and industry experts who have developed and revised the model curriculum for major engineering disciplines. To enhance employability ratio and also enable youngsters to become job creators, the academic and industry experts have accordingly designed the scheme and syllabi. AICTE is thankful to Prof. Rajeev Sangal, Director (IIT-BHU) and his team for developing a Guide to induction program and mandatory non-credit courses such as constitution of India and environment science and engineering. AICTE also acknowledges Bharatiya Vidya Bhawan for developing mandatory non-credit course on Essence of Indian Traditional Knowledge.

The institutions/ universities in India are requested to adopt this "Model Curriculum" for various engineering disciplines. This is a suggestive curriculum and the concerned university/institution is allowed flexibility in readjustment of courses /credits within the overall credit structure of 160 credits in an undergraduate degree program.

AICTE places on record special thanks to Shri R. Subrahmanyam, Special Secretary, MHRD for providing guidance and support throughout the revision of the curriculum.

(Prof. Anil D. Sahasrabudhe)

PREFACE

There has been a concern about quality of technical education in India although in terms of access and equity, India has done very well. AICTE is mandated for planned and coordinated development of Technical Education; regulate proper maintenance of norms & standards and expansion of technical Education with Quality. Accordingly, AICTE in its 49th meeting of the Council held on 14.3.2017 approved a package of measures for improving quality of technical education in the country. Revision of Curriculum, Mandatory Internship and Induction Program were amongst the few major quality initiatives taken by AICTE.

AICTE, in consultation with MHRD constituted subject-wise Heads of the Committees with a respective team of academic experts along with industry expert to draft the model curriculum of UG engineering courses along with Induction Program for students.

During the meetings held for developing model curriculum for undergraduate engineering courses, a concern was shared that in the present system, the first year syllabus is heavily loaded and it is of utmost importance that the students entering into the first year of an engineering course should feel at ease by lowering the burden of syllabus and credits. This is necessary for a student to acclimatize to the new environment of a college and to create a bonding between the teacher and a student. An idea to introduce induction program in the curriculum to equip the students with communication skills, and get them acquainted with the culture of institution and human values was formalized. A student has to undergo this induction program after joining the institute and before the commencement of classes. Normal classes of the engineering program shall begin after the students have undergone a three-weeks induction program. The Induction program for students comprises of Physical activities; Learning an art form; Literature & Cinema; Social Awareness; Lectures &Visits; Universal Human Values; Familiarization to Department/Branch, College& Innovations. To sensitize on the need of induction program, one-day workshops for Principals/ Directors/ Promoters of Society/Trust/Institutions were held at Hyderabad, Bangalore, Mumbai, Kolkata and Delhi. Subsequently, five-day Teacher Training workshops for Student induction were also held at Hyderabad, Varanasi and Pune.

Also, AICTE has made 6-8 weeks summer internships mandatory before completion of under graduation. This will equip the students with practical understanding and training about industry practices in a suitable industry or organization.

A novel concept of Virtual Laboratories has also been introduced in the Model Curriculum. MHRD has successfully completed two phases of project under NPTEL, to develop Virtual Labs through a consortium headed by IIT Delhi. During these phases, more than 180 labs were developed, comprising of more than 1700 experiments, in different domains of engineering. These experiments are field tested through various nodal centres across the country. The Virtual Labs. essentially comprise of a user-friendly graphical front. It would be a far enriching experience to use virtual labs and learn at one's own pace and time. A student can even learn the skills which are not part of the curriculum but required as professionals to take up new challenges. A chapteron 'Virtual Laboratories: A new way of Learning' is a part of this Model Curriculum.

It was also felt that students should get holistic education which has components of sports, physical activities, values and ethics.

The respective Heads of the Committees & teams discussed the existing system prevalent in engineering colleges, industry requirements and market trends, employability, problem solving approach, need for life long learning and after due deliberations, the scheme and syllabus for various engineering disciplines have been formalized. Salient features of this model curriculum are enumerated below:

i. Induction program has been made a part of this Model Curriculum.

ii. Model Curriculum has been designed in such a way that it encourages innovation and research as total number of credits have been reduced and many new courses have been incorporated in consultation with industry experts.

iii. The revised Model Curriculum has been designed where the students can understand the industry requirements and have hands-on experience. The students will develop a problem solving approach and will be able to meet the challenges of future.

iv. It is also understood that different engineering disciplines should have some flexibility in being different. All engineering disciplines cannot be made to conform to a fixed structure. Though, AICTE has compiled a common first year scheme and syllabi for engineering disciplines, the concerned Institution/ University may adjust the scheme and courses as per the requirement of particular Institute and local needs. However, the total credit structure of 160 credits should not be disturbed. The institutions/ universities in India are requested to adopt this "Model Curriculum" for various undergraduate degree engineering disciplines.

v. Courses on Constitution of India, Environment Science/Engg. and Essence of India Traditional Knowledge have also been included in the Curriculum.

vi. A novel concept of Virtual laboratories has been introduced in the model curriculum.

vii. Curriculum on Entrepreneurship is included to support AICTE's start-up policy.

viii. In some disciplines, courses have been mentioned in the scheme, it is left to the University/Institution to frame the detailed syllabus as per their need or can find the same in the AICTE model curriculum of some other disciplines in this booklet.

ix. AICTE will ensure the revision of the model curriculum on regular basis and this updation will certainly help students to achieve better employability; start-ups and other avenues for higher studies.

****

ACKNOWLEDGEMENT

The development of an outcome based Model Curriculum for Undergraduate degree courses in Engineering & Technology is a result of thoughtful deliberations at various stages of dedicated and specialized experts. This model curriculum has been framed to meet the expectations of an academically challenging environment, develop problem solving skills by students, align with current standards and to enrich the students learning to make them self-enablers and/or match job requirements on successful completion of their degree.

I wish to acknowledge all our esteemed experts who have been involved in the process of developing this outcome based model curriculum for various disciplines of undergraduate courses for adoption at various engineering Institutions and Universities. We are thankful to our Heads of the committees of different branches Prof. Anurag Mehra; Dr. D.N. Singh ;Dr. R.K. Shevgaonkar; Prof. T. Sundararajan; Prof. Prathap Haridoss; Prof. Anupam Basu; Dr Anil Kulkarni; Prof.Bhaba K. Sarma, ; Prof. B. L. Tembe and Prof. Manoj Harbola with their team of Academic and Industry experts who were devotedly committed towards framing this model curriculum for various engineering disciplines. We are thankful to Prof. Rajeev Sangal, Director (IIT-BHU)and his teamfor developing a Guide to Induction Program along with mandatory and humanities courses. AICTE also acknowledges Bharatiya Vidya Bhawan for developing mandatory course on Essence of Indian Traditional Knowledge.

A novel concept of Virtual Labs. has been introduced in the Model curriculum to provide remote-access to Labs in various disciplines of Science and Engineering. I am extremely thankful to Prof. S.D. Agashe for preparing contents of Virtual Laboratories for various engineering disciplines.

I am greatly gratified to Shri R. Subrahmanyam, Special Secretary, MHRD for his supervision, contribution, guidance and support throughout the development of this model curriculum.

Special thanks and gratitude to Prof. Anil D. Sahasrabdhe, Chairman; Prof M.P. Poonia, Vice Chairman and Prof. A.P. Mittal, Member Secretary, AICTE who all have been instrumental and encouraging throughout the process of developing this model curriculum.

I like to appreciate the officers and officials of Policy & Academic Planning Bureau, in particular the dedication put in by Ms. Neera Kakkarby compiling the inputs from the experts and coordinating the whole process.

Last, but not the least, I also sincerely thank all officers and officials of AICTE, who have contributed in one way or other for the development of this Model curriculum.

Thanking all once again and seeking continued support…………..

(Prof. Rajive Kumar)
Adviser-I
Policy & Academic Planning Bureau, AICTE

Subject-wise Committees for Model Curriculum of Under Graduate Degree Engineering:

AICTE places on record its appreciation and thankfulness to the respective Heads of Committee along with their team of academic experts and industry experts:

1. **Chemical Engineering**

Head of the curriculum committee: **Prof. Anurag Mehra**,
Department Chemical EngineeringIIT Bombay,
Powai, Maharashtra, Mumbai-400 076

Team of Academic & Industry expert :

Prof. Deepak Kunzru Distinguished Professor School of Engineering and Applied Science Ahmedabad University, Ahmedabad	**Prof. Shantanu Roy** Professor Department of Chemical Engineering IIT Delhi, New Delhi
Prof. Ashwin Patwardhan Professor Department of Chemical Engineering Institute of Chemical Technology Mumbai	**Industry expert** **Dr Ravi Mariwala** Managing Director, Scientific Precision Pvt. Ltd. Scientific Precision Pvt. Ltd. Mumbai

2. **Civil Engineering**

Head of the curriculum committee: **Dr. D. N. Singh**
Institute Chair Professor Dept. of Civil Engineering Geotechnical Engineering Division
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Team of Academic & Industry expert :

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Prof. Ligy Phillips, Dept. of Civil Engg., IIT Madras	**Prof. A. Veeraragavan,** Dept. of Civil Engg., IIT Madras IIT Madras
Industry expert **Prof. N. Raghavan (Ex L&T),** Professor of Practice IIT Madras 215B, BSB, IIT Madras, Chennai 600036	

3. **Electronics and Communication Engineering**

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Team of Academic & Industry expert :

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Prof. S.P. Mahajan COEP, Pune	**Industry expert** **Dr. KushalTuckley** AGV Systems Pvt Ltd, Mumbai

4. **Mechanical Engineering**
Head of the curriculum committee: **Prof. T. Sundararajan**
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Team of Academic & Industry expert:

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Prof. S.K. Saha Professor & Head of the Department Indian Institute of Technology Delhi, New Delhi	**Industry Expert** **Dr. R. Mahadevan, FNAE** Director, India Pistons Ltd, Chennai

5. **Metallurgical Engineering and Materials Science**
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Prof. S. Sankaran Department of Metallurgical and Materials Engineering IIT Madras, Chennai	**Industry Expert** **Sh. Satish Pai** Managing Director, Hindlaco Industries Ltd. Mumbai

6. **Computer Science & Engineering**
Head of the curriculum committee: **Prof. Anupam Basu**,
Chairman and Head, Center for Educational
Technology (CET) & Professor, Dept of Computer
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Team of Academic & Industry expert:

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Prof. PabitraMitra IIT Kharagpur	**Industry Expert** **Dr. Monojit Choudhury** Microsoft Research India

7. Electrical Engineering

Head of the curriculum committee: **Dr Anil Kulkarni**
Professor, Dept of EE, IIT Bombay,
Powai, Mumbai 400076

Team of Academic & Industry expert :

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Industry Expert **Dr. Shashank Wekhande,** Avant Garde Solutions Pvt Ltd, Mumbai	

8. Mathematics

Head of the curriculum committee: **Prof. Bhaba K. Sarma**
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9. Chemistry, Biochemistry and Biology

Head of the curriculum committee: **Prof. B. L. Tembe**
Chemistry and Biochemistry, Indian Institute of Technology Bombay, Powai, Maharashtra, Mumbai-400 076

Team of Academic & Industry expert :

Prof. P. Jayadeva Bhat Department of Bio-sciences and Bio-engineering IIT Bombay	**Prof. Santosh J. Gharpure** Department of Chemistry IIT Bombay

10. Physics

Head of the curriculum committee: **Prof. Manoj Harbola**
Physics, Indian Institute of Technology Kanpur Uttar Pradesh, Kanpur-208 016

Team of Academic & Industry expert :

Dr. Deepak Gupta IIT Kanpur	**Dr. Shilpa Gupta** EE, IIT Kanpur

11. Induction program, Mandatory courses and Humanities; Social Sciences including Management courses

Head of the curriculum committee: **Prof. Rajeev Sangal**
Director
Indian institute of Technology
(Banaras Hindu University)
Varanasi 221 005

Team of Academic & Industry expert :

Prof. N. C. Karmakar Mining Engg., IIT-BHU	**Prof. R. K. Mishra** Electrical Engg., IIT-BHU
Prof. Pradeep Ramancharla Civil Engg., IIIT Hyderabad	**Industry Expert** **Prof. Rajul Asthana** Ex-Sr.Vice President, Satyam Computers, Hyderabad

12. Essence of Indian Traditional Knowledge (Part 1 and 2)
Bharatiya Vidya Bhavan, New Delhi

13. Prof. S.D. Agashe, Professor (Instrumentation & Control Engg) , College of Engineering, Pune,

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All India Council for Technical Education

MODEL CURRICULUM

For

UNDERGRADUATE DEGREE COURSES
IN
ENGINEERING & TECHNOLOGY

Volume I

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MODEL CURRICULUM

for

FIRST YEAR
UNDERGRADUATE DEGREE COURSES
IN

ENGINEERING & TECHNOLOGY

[January 2018]

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Nelson Mandela Marg, Vasant Kunj, New Delhi 110 070
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Model Curriculum for
First Year
Undergraduate Degree Courses in Engineering & Technology

CONTENTS

Sl. No.	Chapter	Title
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2	**2**	**Detailed First Year Curriculum Contents** (Common to all branches UG Engineering &Technology)
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		Physics (Theory & Lab.)
		Mathematics –1
		Mathematics -2
		Mathematics (for Computer Science & Engineering students)
		Programming for Problem Solving (Theory & Lab.)
		English
		Engineering Graphics & Design
		Workshop/Manufacturing Practices (Theory & lab.)
		Basic Electrical Engineering (Theory & Lab.)
3	**Appendix –A**	Guide to Induction program

Model Curriculum for
First Year
Undergraduate Degree Courses in Engineering & Technology

Chapter -1

General, Course structure & Theme
&
Semester-wise credit distribution

A. Definition of Credit:

1 Hr. Lecture (L) per week	1 credit
1 Hr. Tutorial (T) per week	1 credit
1 Hr. Practical (P) per week 2 Hours Practical(Lab)/week	0.5 credits 1 credit

B. Range of credits –

A range of credits from 150 to 160 for a student to be eligible to get Under Graduate degree in Engineering. A student will be eligible to get Under Graduate degree with Honours or additional Minor Engineering, if he/she completes an additional 20 credits. These could be acquired through MOOCs.

C. Structure of Undergraduate Engineering program:

S. No.	Category	Suggested Breakup of Credits(Total 160)
1	Humanities and Social Sciences including Management courses	12*
2	Basic Science courses	25*
3	Engineering Science courses including workshop, drawing, basics of electrical/mechanical/computer etc	24*
4	Professional core courses	48*
5	Professional Elective courses relevant to chosen specialization/branch	18*
6	Open subjects – Electives from other technical and /or emerging subjects	18*
7	Project work, seminar and internship in industry or elsewhere	15*
8	Mandatory Courses [Environmental Sciences, Induction training, Indian Constitution, Essence of Indian Traditional Knowledge]	(non-credit)
	Total	160*

**Minor variation is allowed as per need of the respective disciplines.*

D. Credit distribution in the First year of Undergraduate Engineering program:

	Lecture (L)	**Tutorial (T)**	**Laboratory/Practical (P)**	**Total credits (C)**
Chemistry -I	3	1	3	5.5
Physics	3	1	3	5.5
Maths-1	3	1	0	4
Maths -2	3	1	0	4
Programming for Problem solving	3	0	4	5
English	2	0	2	3
Engineering Graphics & Design	1	0	4	3
Workshop/ Practicals	1	0	4	3
Basic Electrical Engg.	3	1	2	5
*Biology	2	1	0	3
*Engg. Mechanics	3	1	0	4
*Maths-3	3	1	0	4

**These courses may be offered preferably in the 3rd semester & onwards.*

E. Course code and definition:

Course code	**Definitions**
L	Lecture
T	Tutorial
P	Practical
BSC	Basic Science Courses
ESC	Engineering Science Courses
HSMC	Humanities and Social Sciences including Management courses
PCC	Professional core courses
PEC	Professional Elective courses
OEC	Open Elective courses
LC	Laboratory course
MC	Mandatory courses
PROJ	Project

F. Category of Courses:

BASIC SCIENCE COURSES

Sl. No.	Course Code	Course Title	Hours per week			Credits	Preferred semester
			L	T	P		
2	BSC101	Physics	3	1	3	5.5	I
1	BSC102	Chemistry-I	3	1	3	5.5	II
3	BSC103	Mathematics –I	3	1	0	4	I
4	BSC104	Mathematics –2	3	1	0	4	II

ENGINEERING SCIENCE COURSES

Sl. No.	Course Code	Course Title	Hours per week			Credits	Preferred semester
			L	T	P		
1	ESC101	Basic Electrical Engineering	3	1	2	5	I
2	ESC102	Engineering Graphics & Design	1	0	4	3	I
3	ESC103	Programming for Problem Solving	3	0	4	5	II
4	ESC104	Workshop/Manufacturing Practices	1	0	4	3	II

HUMANITIES & SOCIAL SCIENCES INCLUDING MANAGEMENT

Sl. No.	Course Code	Course Title	Hours per week			Credits	Preferred Semester
			L	T	P		
1	HSMC101	English	2	0	2	3	II

G. Structure of curriculum

Mandatory Induction Program

3 weeks duration

- Physical activity
- Creative Arts
- Universal Human Values
- Literary
- Proficiency Modules
- Lectures by Eminent People
- Visits to local Areas
- Familiarization to Dept./Branch & Innovations

Semester I (First year]
Branch/Course Common to all branches of UG Engineering & Technology

Sl. No.	Category	Course Code	Course Title	Hours per week			Credits
				L	T	P	
1	Basic Science course	BSC101	Physics	3	1	3	5.5
2	Basic Science course	BSC103	Mathematics –I	3	1	0	4
3	Engineering Science Courses	ESC101	Basic Electrical Engineering	3	1	2	5
4	Engineering Science Courses	ESC102	Engineering Graphics & Design	1	0	4	3
			Total credits				**17.5**

Semester II (First year)
Branch/Course : Common to all branches of UG Engineering & Technology

Sl. No.	Category	Code	Course Title	Hours per week			Credits
				L	T	P	
1	Basic Science courses	BSC 102	Chemistry-I	3	1	3	5.5
2	Basic Science courses	BSC 104	Mathematics –II	3	1	0	4
3	Engineering Science Courses	ESC103	Programming for Problem Solving	3	0	4	5
4	Engineering Science Courses	ESC104	Workshop/Manufacturing Practices	1	0	4	3
5	Humanities and Social Sciences including Management courses	HSMC101	English	2	0	2	3
						Total credits	**20.5**

Chapter -2
Detailed first year curriculum contents

I. Mandatory Induction program

(Please refer **Appendix-A** for guidelines. Details of Induction program also available in the curriculum of Mandatory courses.)
[Induction program for students to be offered right at the start of the first year.]

3 weeks duration
• Physical activity • Creative Arts • Universal Human Values • Literary • Proficiency Modules • Lectures by Eminent People • Visits to local Areas • Familiarization to Dept./Branch & Innovations

II. Undergraduate Degree courses

Course code	BSC102				
Category	Basic Science Course				
Course title	**Chemistry-I (Theory & Lab.)** **Contents** (i) Chemistry-I (Concepts in chemistry for engineering) (ii) Chemistry Laboratory				
Scheme and Credits	**L**	**T**	**P**	**Credits**	Semester –II
	3	**1**	**3**	**5.5**	
Pre-requisites (if any)	**-**				

(i)Chemistry-I (Concepts in chemistry for engineering) [L : 3; T:1; P : 0 (4 credits)]

Detailed contents

(i) Atomic and molecular structure (12 lectures)

Schrodinger equation. Particle in a box solutions and their applications for conjugated molecules and nanoparticles. Forms of the hydrogen atom wave functions and the plots of these functions to explore their spatial variations. Molecular orbitals of diatomic molecules and plots of the multicenter orbitals. Equations for atomic and molecular orbitals. Energy level diagrams of diatomic. Pi-molecular orbitals of butadiene and benzene and aromaticity. Crystal field theory and the energy level diagrams for transition metal ions and their magnetic properties. Band structure of solids and the role of doping on band structures.

(ii) Spectroscopic techniques and applications (8 lectures)

Principles of spectroscopy and selection rules. Electronic spectroscopy. Fluorescence and its applications in medicine. Vibrational and rotational spectroscopy of diatomic molecules. Applications. Nuclear magnetic resonance and magnetic resonance imaging, surface characterisation techniques. Diffraction and scattering.

(iii) Intermolecular forces and potential energy surfaces (4 lectures)

Ionic, dipolar and van Der Waals interactions. Equations of state of real gases and critical phenomena. Potential energy surfaces of H_3, H_2F and HCN and trajectories on these surfaces.

(iv) Use of free energy in chemical equilibria (6 lectures)

Thermodynamic functions: energy, entropy and free energy. Estimations of entropy and free energies. Free energy and emf. Cell potentials, the Nernst equation and applications. Acid base, oxidation reduction and solubility equilibria. Water chemistry. Corrosion. Use of free energy considerations in metallurgy through Ellingham diagrams.

(v) Periodic properties (4 Lectures)

Effective nuclear charge, penetration of orbitals, variations of s, p, d and f orbital energies of atoms in the periodic table, electronic configurations, atomic and ionic sizes, ionization energies, electron affinity and electronegativity, polarizability, oxidation states, coordination numbers and geometries, hard soft acids and bases, molecular geometries

(vi) Stereochemistry (4 lectures)

Representations of 3 dimensional structures, structural isomers and stereoisomers, configurations and symmetry and chirality, enantiomers, diastereomers, optical activity, absolute configurations and conformational analysis. Isomerism in transitional metal compounds

(vii) Organic reactions and synthesis of a drug molecule (4 lectures)

Introduction to reactions involving substitution, addition, elimination, oxidation, reduction, cyclization and ring openings. Synthesis of a commonly used drug molecule.

Suggested Text Books

(i) University chemistry, by B. H. Mahan
(ii) Chemistry: Principles and Applications, by M. J. Sienko and R. A. Plane
(iii) Fundamentals of Molecular Spectroscopy, by C. N. Banwell
(iv) Engineering Chemistry (NPTEL Web-book), by B. L. Tembe, Kamaluddin and M. S. Krishnan
(v) Physical Chemistry, by P. W. Atkins
(vi) Organic Chemistry: Structure and Function by K. P. C. Volhardt and N. E. Schore, 5th Edition http://bcs.whfreeman.com/vollhardtschore5e/default.asp

Course Outcomes

The concepts developed in this course will aid in quantification of several concepts in chemistry that have been introduced at the 10+2 levels in schools. Technology is being increasingly based on the electronic, atomic and molecular level modifications.

Quantum theory is more than 100 years old and to understand phenomena at nanometer levels, one has to base the description of all chemical processes at molecular levels. The course will enable the student to:

- Analyse microscopic chemistry in terms of atomic and molecular orbitals and intermolecular forces.
- Rationalise bulk properties and processes using thermodynamic considerations.
- Distinguish the ranges of the electromagnetic spectrum used for exciting different molecular energy levels in various spectroscopic techniques
- Rationalise periodic properties such as ionization potential, electronegativity, oxidation states and electronegativity.
- List major chemical reactions that are used in the synthesis of molecules.

(ii)Chemistry Laboratory[L : 0; T:0 ; P : 3 (1.5 credits)]

Choice of 10-12 experiments from the following:

- Determination of surface tension and viscosity
- Thin layer chromatography
- Ion exchange column for removal of hardness of water
- Determination of chloride content of water
- Colligative properties using freezing point depression
- Determination of the rate constant of a reaction
- Determination of cell constant and conductance of solutions
- Potentiometry - determination of redox potentials and emfs
- Synthesis of a polymer/drug

- Saponification/acid value of an oil
- Chemical analysis of a salt
- Lattice structures and packing of spheres
- Models of potential energy surfaces
- Chemical oscillations- Iodine clock reaction
- Determination of the partition coefficient of a substance between two immiscible liquids
- Adsorption of acetic acid by charcoal
- Use of the capillary viscosimeters to the demonstrate of the isoelectric point as the pH of minimum viscosity for gelatin sols and/or coagulation of the white part of egg .

Laboratory Outcomes

- The chemistry laboratory course will consist of experiments illustrating the principles of chemistry relevant to the study of science and engineering. The students will learn to:
- Estimate rate constants of reactions from concentration of reactants/products as a function of time
- Measure molecular/system properties such as surface tension, viscosity, conductance of solutions, redox potentials, chloride content of water, etc
- Synthesize a small drug molecule and analyse a salt sample

<table>
<tr><td>**Course code**</td><td colspan="5">BSC101</td></tr>
<tr><td>Category</td><td colspan="5">Basic Science Course</td></tr>
<tr><td>**Course title**</td><td colspan="5">**Physics (Theory & Lab.)**</td></tr>
<tr><td rowspan="2">**Scheme and Credits**</td><td>**L**</td><td>**T**</td><td>**P**</td><td>**Credits**</td><td rowspan="2">Semester-I</td></tr>
<tr><td>**3**</td><td>**1**</td><td>**3**</td><td>**5.5**</td></tr>
<tr><td></td><td colspan="5">**Course contents in Physics(Any one)**
(i) Introduction to Electromagnetic Theory
(ii) Introduction to Mechanics
(iii) Quantum Mechanics for Engineers
(iv) Oscillation, Waves and Optics</td></tr>
</table>

(i)Introduction to Electromagnetic Theory[L : 3; T:1; P : 0 (4 credits)]

Pre-requisites (if any)	Mathematics course with vector calculus

Detailed contents:

Module 1: Electrostatics in vacuum (8 lectures)

Calculation of electric field and electrostatic potential for a charge distribution; Divergence and curl of electrostatic field; Laplace's and Poisson's equations for electrostatic potential and uniqueness of their solution and connection with steady state diffusion and thermal conduction; Practical examples like Farady's cage and coffee-ring effect; Boundary conditions of electric field and electrostatic potential; method of images; energy of a charge distribution and its expression in terms of electric field.

Module 2: Electrostatics in a linear dielectric medium (4 lectures)

Electrostatic field and potential of a dipole. Bound charges due to electric polarization; Electric displacement; boundary conditions on displacement; Solving simple electrostatics problems in presence of dielectrics – Point charge at the centre of a dielectric sphere, charge in front of a dielectric slab, dielectric slab and dielectric sphere in uniform electric field.

Module 3: Magnetostatics(6 lectures)

Bio-Savart law, Divergence and curl of static magnetic field; vector potential and calculating it for a given magnetic field using Stokes' theorem; the equation for the vector potential and its solution for given current densities.

Module 4: Magnetostatics in a linear magnetic medium (3 lectures)

Magnetization and associated bound currents; auxiliary magnetic field $\vec{H}$; Boundary conditions on $\vec{B}$and$\vec{H}$. Solving for magnetic field due to simple magnets like a bar magnet; magnetic susceptibility and ferromagnetic, paramagnetic and diamagnetic materials; Qualitative discussion of magnetic field in presence of magnetic materials.

Module 5: Faraday's law (4 lectures)

Faraday's law in terms of EMF produced by changing magnetic flux; equivalence of Faraday's law and motional EMF; Lenz's law; Electromagnetic breaking and its applications; Differential form of Faraday's law expressing curl of electric field in terms of time-derivative of magnetic field and calculating electric field due to changing magnetic fields in quasi-static approximation; energy stored in a magnetic field.

Module 6: Displacement current, Magnetic field due to time-dependent electric field and Maxwell's equations (5 lectures)

Continuity equation for current densities; Modifying equation for the curl of magnetic field to satisfy continuity equation; displace current and magnetic field arising from time-dependent electric field; calculating magnetic field due to changing electric fields in quasi-static approximation. Maxwell's equation in vacuum and non-conducting medium; Energy in an electromagnetic field; Flow of energy and Poynting vector with examples. Qualitative discussion of momentum in electromagnetic fields.

Module 7: Electromagnetic waves (8 lectures)

The wave equation; Plane electromagnetic waves in vacuum, their transverse nature and polarization; relation between electric and magnetic fields of an electromagnetic wave; energy carried by electromagnetic waves and examples. Momentum carried by electromagnetic waves and resultant pressure. Reflection and transmission of electromagnetic waves from a non-conducting medium-vacuum interface for normal incidence.

Suggested Text Books

(i) David Griffiths, Introduction to Electrodynamics

Suggested Reference Books:

(i) Halliday and Resnick, Physics
(ii) W. Saslow, Electricity, magnetism and light

Course Outcomes

- To be uploaded

- **Laboratory - Introduction to Electromagnetic Theory[L: 0; T:0 ; P : 3 (1.5 credits)]**

Choice of experiments from the following:

- Experiments on electromagnetic induction and electromagnetic breaking;
- LC circuit and LCR circuit;
- Resonance phenomena in LCR circuits;
- Magnetic field from Helmholtz coil;
- Measurement of Lorentz force in a vacuum tube.

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(ii)Introduction to Mechanics[L : 3; T:1; P : 0 (4 credits)]

Pre-requisites (if any)	High-school education

Detailed contents:

Module 1: (8 lectures)

Transformation of scalars and vectors under Rotation transformation; Forces in Nature; Newton's laws and its completeness in describing particle motion; Form invariance of Newton's Second Law; Solving Newton's equations of motion in polar coordinates; Problems including constraints and friction; Extension to cylindrical and spherical coordinates

Module 2: (7 lectures)

Potential energy function; F = - Grad V, equipotential surfaces and meaning of gradient; Conservative and non-conservative forces, curl of a force field; Central forces; Conservation of Angular Momentum; Energy equation and energy diagrams; Elliptical, parabolic and hyperbolic orbits; Kepler problem; Application: Satellite manoeuvres;

Module 3: (5 lectures)

Non-inertial frames of reference; Rotating coordinate system: Five-term acceleration formula.

Centripetal and Coriolis accelerations; Applications: Weather systems, Foucault pendulum;

Module 4: (6 lectures)

Harmonic oscillator; Damped harmonic motion – over-damped, critically damped and lightly-damped oscillators; Forced oscillations and resonance.

Module 5: (5 lectures)

Definition and motion of a rigid body in the plane; Rotation in the plane; Kinematics in a coordinate system rotating and translating in the plane; Angular momentum about a point of a rigid body in planar motion; Euler's laws of motion, their independence from Newton's laws, and their necessity in describing rigid body motion; Examples.

Module 6: (7 lectures)

Introduction to three-dimensional rigid body motion — only need to highlight the distinction from two-dimensional motion in terms of (a) Angular velocity vector, and its rate of change and (b) Moment of inertia tensor; Three-dimensional motion of a rigid body wherein all points move in a coplanar manner: e.g. Rod executing conical motion with center of mass fixed — only need to show that this motion looks two-dimensional but is three-dimensional, and two-dimensional formulation fails.

Suggested Reference Books

(i) Engineering Mechanics, 2nd ed. — MK Harbola
(ii) Introduction to Mechanics — MK Verma
(iii) An Introduction to Mechanics — D Kleppner& R Kolenkow
(iv) Principles of Mechanics — JL Synge & BA Griffiths
(v)Mechanics — JP Den Hartog
(vi) Engineering Mechanics - Dynamics, 7th ed. - JL Meriam
(vii) Mechanical Vibrations — JP Den Hartog
(viii)Theory of Vibrations with Applications — WT Thomson

Course Outcomes

- To be uploaded

❖ **Laboratory - Introduction to Mechanics[L : 0; T:0 ; P : 3 (1.5 credits)]**

Suggested list of experiments from the following:

- Coupled oscillators;
- Experiments on an air-track;
- Experiment on moment of inertia measurement,
- Experiments with gyroscope;
- Resonance phenomena in mechanical oscillators.

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(iii) Quantum Mechanics for Engineers[L : 3; T:1; P : 0 (4 credits)]

Pre-requisites (if any)	Mathematics course on differential equations and linear algebra

Detailed contents :

Module 1: Wave nature of particles and the Schrodinger equation (8 lectures)

Introduction to Quantum mechanics, Wave nature of Particles, Time-dependent and time-independent Schrodinger equation for wavefunction, Born interpretation, probability current, Expectation values, Free-particle wavefunction and wave-packets, Uncertainty principle.

Module 2: Mathematical Preliminaries for quantum mechanics (4 lectures)

Complex numbers, Linear vector spaces, inner product, operators, eigenvalue problems, Hermitian operators, Hermite polynomials, Legendre’s equation, spherical harmonics.

Module 3: Applying the Schrodinger equation (15 lectures)

Solution of stationary-state Schrodinger equation for one dimensional problems– particle in a box, particle in attractive delta-function potential, square-well potential, linear harmonic oscillator.

Numerical solution of stationary-state Schrodinger equation for one dimensional problems for different potentials

Scattering from a potential barrier and tunneling; related examples like alpha-decay, field-ionization and scanning tunneling microscope

Three-dimensional problems: particle in three dimensional box and related examples, Angular momentum operator, Rigid Rotor, Hydrogen atom ground-state, orbitals, interaction with magnetic field, spin

Numerical solution stationary-state radial Schrodinger equation for spherically symmetric potentials.

Module 4: Introduction to molecular bonding (4 lectures)

Particle in double delta-function potential, Molecules (hydrogen molecule, valence bond and molecular orbitals picture), singlet/triplet states, chemical bonding, hybridization

Module 5: Introduction to solids (7 lectures)

Free electron theory of metals, Fermi level, density of states, Application to white dwarfs and neutron stars, Bloch's theorem for particles in a periodic potential, Kronig-Penney model and origin of energy bands

Numerical solution for energy in one-dimensional periodic lattice by mixing plane waves.

Suggested Text Books

(i) Eisberg and Resnick, Introduction to Quantum Physics

Suggested Reference Books

(i) D. J. Griffiths, Quantum mechanics
(ii) Richard Robinett, Quantum Mechanics
(iii) Daniel McQuarrie, Quantum Chemistry

Course Outcomes

- To be uploaded

❖ **Laboratory - Quantum Mechanics for Engineers[L: 0; T:0 ; P : 3 (1.5 credits)]**

Suggested list of experiments from the following:

Frank-Hertz experiment; photoelectric effect experiment; recording hydrogen atom spectrum

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(iv)Oscillations, waves and optics[L : 3; T:1; P : 0 (4 credits)]

Pre-requisites (if any)	(i) Mathematics course on Differential equations (ii) Introduction to Electromagnetic theory

Detailed contents :

Module 1: Simple harmonic motion, damped and forced simple harmonic oscillator (7 lectures)

Mechanical and electrical simple harmonic oscillators, complex number notation and phasor representation of simple harmonic motion, damped harmonic oscillator – heavy, critical and light damping, energy decay in a damped harmonic oscillator, quality factor, forced mechanical and electrical oscillators, electrical and mechanical impedance, steady state motion of forced damped harmonic oscillator, power absorbed by oscillator.

Module 2: Non-dispersive transverse and longitudinal waves in one dimension and introduction to dispersion (7 lectures)

Transverse wave on a string, the wave equation on a string, Harmonic waves, reflection and transmission of waves at a boundary, impedance matching, standing waves and their Eigen frequencies, longitudinal waves and the wave equation for them, acoustics waves and speed of sound, standing sound waves.

Waves with dispersion, water waves, superposition of waves and Fourier method, wave groups and group velocity.

Module 3: The propagation of light and geometric optics (10 lectures)

Fermat's principle of stationary time and its applications e.g. in explaining mirage effect, laws of reflection and refraction, Light as an electromagnetic wave and Fresnel equations, reflectance and transmittance, Brewster's angle, total internal reflection, and evanescent wave. Mirrors and lenses and optical instruments based on them, transfer formula and the matrix method.

Module 4: Wave optics (6 lectures)

Huygens' principle, superposition of waves and interference of light by wave front splitting and amplitude splitting; Young's double slit experiment, Newton's rings, Michelson interferometer, Mach-Zehnder interferometer.

Farunhofer diffraction from a single slit and a circular aperture, the Rayleigh criterion for limit of resolution and its application to vision; Diffraction gratings and their resolving power

Module 5: Lasers (8)

Einstein's theory of matter radiation interaction and A and B coefficients; amplification of light by population inversion, different types of lasers: gas lasers (He-Ne, CO_2), solid-state lasers(ruby, Neodymium), dye lasers; Properties of laser beams: mono-chromaticity, coherence, directionality and brightness, laser speckles, applications of lasers in science, engineering and medicine.

Suggested Reference Books

(i) Ian G. Main, Oscillations and waves in physics
(ii) H.J. Pain, The physics of vibrations and waves
(iii)E. Hecht, Optics
(iv)A. Ghatak, Optics
(v)O. Svelto, Principles of Lasers

❖ **Laboratory - Oscillations, waves and optics [L : 0; T:0 ; P : 3 (1.5 credits)]**

Suggested list of experiments from the following:

- Diffraction and interference experiments (from ordinary light or laser pointers); measurement of speed of light on a table top using modulation; minimum deviation from a prism.

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Course code	BSC103				
Category	Basic Science Course				
Course title	**Mathematics -1**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	Semester - I
	3	**1**	**0**	**4**	
Pre-requisites (if any)	-				

(i)Calculus and Linear Algebra

Detailed contents:

Module 1: Calculus: (6 lectures)

Evolutes and involutes; Evaluation of definite and improper integrals; Beta and Gamma functions and their properties; Applications of definite integrals to evaluate surface areas and volumes of revolutions.

Module 2: Calculus: (6 lectures)

Rolle's Theorem, Mean value theorems, Taylor's and Maclaurin theorems with remainders; indeterminate forms and L'Hospital's rule; Maxima and minima.

Module 3: Sequences and series: (10 lectures)

Convergence of sequence and series, tests for convergence; Power series, Taylor's series, series for exponential, trigonometric and logarithm functions; Fourier series: Half range sine and cosine series, Parseval's theorem.

Module 4: Multivariable Calculus (Differentiation): (8 lectures)

Limit, continuity and partial derivatives, directional derivatives, total derivative; Tangent plane and normal line; Maxima, minima and saddle points; Method of Lagrange multipliers; Gradient, curl and divergence.

Module 5: Matrices (10 lectures)

Inverse and rank of a matrix, rank-nullity theorem; System of linear equations; Symmetric, skew-symmetric and orthogonal matrices; Determinants; Eigenvalues and eigenvectors; Diagonalization of matrices; Cayley-Hamilton Theorem, and Orthogonal transformation.

Suggested Text/Reference Books

(i) G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Edition, Pearson, Reprint, 2002.
(ii) Erwin kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
(iii) Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.
(iv) Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11th Reprint, 2010.
(v) D. Poole, Linear Algebra: A Modern Introduction, 2nd Edition, Brooks/Cole, 2005.
(vi) N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2008.
(vii) B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36th Edition, 2010.

Course Outcomes

The objective of this course is to familiarize the prospective engineers with techniques in calculus, multivariate analysis and linear algebra. It aims to equip the students with standard concepts and tools at an intermediate to advanced level that will serve them well towards tackling more advanced level of mathematics and applications that they would find useful in their disciplines.

The students will learn:

- To apply differential and integral calculus to notions of curvature and to improper integrals. Apart from some other applications they will have a basic understanding of Beta and Gamma functions.
- The fallouts of Rolle's Theorem that is fundamental to application of analysis to Engineering problems.
- The tool of power series and Fourier series for learning advanced Engineering Mathematics.
- To deal with functions of several variables that are essential in most branches of engineering.
- The essential tool of matrices and linear algebra in a comprehensive manner.

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Course code	BSC104				
Category	Basic Science Course				
Course title	**Mathematics -2** **(Calculus, Ordinary Differential Equations and Complex Variable)**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	Semester-II
	3	**1**	**0**	**4**	
Pre-requisites (if any)	**-**				

Calculus, Ordinary Differential Equations and Complex Variable

Detailed contents

Module 1: Multivariable Calculus (Integration): (10 lectures)

Multiple Integration: Double integrals (Cartesian), change of order of integration in double integrals, Change of variables (Cartesian to polar), Applications: areas and volumes, Center of mass and Gravity (constant and variable densities); Triple integrals (Cartesian), orthogonal curvilinear coordinates, Simple applications involving cubes, sphere and rectangular parallelepipeds; Scalar line integrals, vector line integrals, scalar surface integrals, vector surface integrals, Theorems of Green, Gauss and Stokes.

Module 2: First order ordinary differential equations: (6 lectures)

Exact, linear and Bernoulli's equations, Euler's equations, Equations not of first degree: equations solvable for p, equations solvable for y, equations solvable for x and Clairaut's type.

Module 3: Ordinary differential equations of higher orders: (8 lectures)

Second order linear differential equations with variable coefficients, method of variation of parameters, Cauchy-Euler equation; Power series solutions; Legendre polynomials, Bessel functions of the first kind and their properties.

Module 4: Complex Variable – Differentiation: (8 lectures)

Differentiation, Cauchy-Riemann equations, analytic functions, harmonic functions, finding harmonic conjugate; elementary analytic functions (exponential, trigonometric, logarithm) and their properties; Conformal mappings, Mobius transformations and their properties.

Module 5: Complex Variable – Integration: (8 lectures)

Contour integrals, Cauchy-Goursat theorem (without proof), Cauchy Integral formula (without proof), Liouville's theorem and Maximum-Modulus theorem (without proof); Taylor's series, zeros of analytic functions, singularities, Laurent's series; Residues, Cauchy Residue theorem (without proof), Evaluation of definite integral involving sine and cosine, Evaluation of certain improper integrals using the Bromwich contour.

Suggested Text/Reference Books

(i) G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Edition, Pearson, Reprint, 2002.
(ii) Erwin kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
(iii) W. E. Boyce and R. C. DiPrima, Elementary Differential Equations and Boundary Value Problems, 9th Edn., Wiley India, 2009.
(iv) S. L. Ross, Differential Equations, 3rd Ed., Wiley India, 1984.
(v) E. A. Coddington, An Introduction to Ordinary Differential Equations, Prentice Hall India, 1995.
(vi) E. L. Ince, Ordinary Differential Equations, Dover Publications, 1958.
(vii) J. W. Brown and R. V. Churchill, Complex Variables and Applications, 7th Ed., Mc-Graw Hill, 2004.
(viii) N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2008.
(ix) B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36th Edition, 2010.

Course Outcomes

The objective of this course is to familiarize the prospective engineers with techniques in multivariate integration, ordinary and partial differential equations and complex variables. It aims to equip the students to deal with advanced level of mathematics and applications that would be essential for their disciplines.

The students will learn:

- The mathematical tools needed in evaluating multiple integrals and their usage.
- The effective mathematical tools for the solutions of differential equations that model physical processes.
- The tools of differentiation and integration of functions of a complex variable that are used in various techniques dealing engineering problems.

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<table>
<tr><td>Course code</td><td colspan="5">BSC105</td></tr>
<tr><td>Category</td><td colspan="5">Basic Science Course</td></tr>
<tr><td>Course title</td><td colspan="5">Mathematics (for Computer Science &Engg. students)
Paper – 1 Calculus and Linear Algebra</td></tr>
<tr><td rowspan="2">Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td rowspan="2"></td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td></tr>
<tr><td>Pre-requisites (if any)</td><td colspan="5">-</td></tr>
</table>

Paper-1 Calculus and Linear Algebra

Detailed contents:

Module 1: Calculus: (6 lectures)

Evolutes and involutes; Evaluation of definite and improper integrals; Beta and Gamma functions and their properties; Applications of definite integrals to evaluate surface areas and volumes of revolutions.

Module 2: Calculus: (6 lectures)

Rolle's theorem, Mean value theorems, Taylor's and Maclaurin theorems with remainders; Indeterminate forms and L'Hospital's rule; Maxima and minima.

Module 3: Matrices (in case vector spaces is to be taught) (8 lectures)

Matrices, vectors: addition and scalar multiplication, matrix multiplication; Linear systems of equations, linear Independence, rank of a matrix, determinants, Cramer's Rule, inverse of a matrix, Gauss elimination and Gauss-Jordan elimination.

Module 4: Vector spaces (Prerequisite Module 3-Matrices) (10 hours)

Vector Space, linear dependence of vectors, basis, dimension; Linear transformations (maps), range and kernel of a linear map, rank and nullity, Inverse of a linear transformation, rank-nullity theorem, composition of linear maps, Matrix associated with a linear map.

Module 5: Vector spaces (Prerequisite Module 3 –Matrices & Module-4 Vector spaces) (10 lectures)

Eigenvalues, eigenvectors, symmetric, skew-symmetric, and orthogonal Matrices, eigenbases. Diagonalization; Inner product spaces, Gram-Schmidt orthogonalization.

Suggested Text/Reference Books

(i) G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Edition, Pearson, Reprint, 2002.
(ii) Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
(iii) D. Poole, Linear Algebra: A Modern Introduction, 2nd Edition, Brooks/Cole, 2005.
(iv) Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.
(v) Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11th Reprint, 2010.
(vi) N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2010.
(vii) B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition, 2000.
(viii) V. Krishnamurthy, V.P. Mainra and J.L. Arora, An introduction to Linear Algebra, Affiliated East–West press, Reprint 2005.

Course Outcomes

The objective of this course is to familiarize the prospective engineers with techniques in basic calculus and linear algebra. It aims to equip the students with standard concepts and tools at an intermediate to advanced level that will serve them well towards tackling more advanced level of mathematics and applications that they would find useful in their disciplines.

The students will learn:

- To apply differential and integral calculus to notions of curvature and to improper integrals. Apart from various applications, they will have a basic understanding of Beta and Gamma functions.
- The essential tools of matrices and linear algebra including linear transformations, eigenvalues, diagonalization and orthogonalization.

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Course code	BSC106			
Category	Basic Science Course			
Course title	**Mathematics (for Computer Science & Engg. Students)** **Paper – 2 : Probability and Statistics**			
Scheme and Credits	**L**	**T**	**P**	**Credits**
	3	**1**	**0**	**4**
Pre-requisites (if any)	**-**			

Paper -2: Probability and Statistics

Detailed contents

Module 1: Basic Probability: *(12 lectures)*

Probability spaces, conditional probability, independence; Discrete random variables, Independent random variables, the multinomial distribution, Poisson approximation to the binomial distribution, infinite sequences of Bernoulli trials, sums of independent random variables; Expectation of Discrete Random Variables, Moments, Variance of a sum, Correlation coefficient, Chebyshev's Inequality.

Module 2: Continuous Probability Distributions: *(4 lectures)*

Continuous random varibales and their properties, distribution functions and densities, normal, exponential and gamma densities.

Module 3: Bivariate Distributions: *(4 lectures)*

Bivariate distributions and their properties, distribution of sums and quotients, conditional densities, Bayes' rule.

Module 4: Basic Statistics: (8 lectures)

Measures of Central tendency: Moments, skewness and Kurtosis - Probability distributions: Binomial, Poisson and Normal - evaluation of statistical parameters for these three distributions, Correlation and regression – Rank correlation.

Module 5: Applied Statistics: (8 lectures)

Curve fitting by the method of least squares- fitting of straight lines, second degree parabolas and more general curves. Test of significance: Large sample test for single proportion, difference of proportions, single mean, difference of means, and difference of standard deviations.

Module 6: Small samples: (4 lectures)

Test for single mean, difference of means and correlation coefficients, test for ratio of variances - Chi-square test for goodness of fit and independence of attributes.

Suggested Text/Reference Books

(i) Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
(ii) P. G. Hoel, S. C. Port and C. J. Stone, Introduction to Probability Theory, Universal Book Stall, 2003 (Reprint).
(iii) S. Ross, A First Course in Probability, 6th Ed., Pearson Education India, 2002.
(iv) W. Feller, An Introduction to Probability Theory and its Applications, Vol. 1, 3rd Ed., Wiley, 1968.
(v) N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2010.
(vi) B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition, 2000.
(vii) Veerarajan T., Engineering Mathematics (for semester III), Tata McGraw-Hill, New Delhi, 2010.

Course Outcomes

The objective of this course is to familiarize the students with statistical techniques. It aims to equip the students with standard concepts and tools at an intermediate to advanced level that will serve them well towards tackling various problems in the discipline.

The students will learn:

- The ideas of probability and random variables and various discrete and continuous probability distributions and their properties.
- The basic ideas of statistics including measures of central tendency, correlation and regression.
- The statistical methods of studying data samples.

Course code	ESC103				
Category	Engineering Science Course				
Course title	**Programming for Problem Solving (Theory & Lab.)**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	Semester – II
	3	**0**	**4**	**5**	[The lab component should have one hour of tutorial followed or preceded by laboratory assignments.]
Pre-requisites (if any)	-				

(i)Programming for Problem Solving **([L : 3; T:0; P : 0 (3 credits)] [contact hrs : 40]**

Detailed contents

Unit 1Introduction to Programming **(4 lectures)**

Introduction to components of a computer system (disks, memory, processor, where a program is stored and executed, operating system, compilers etc.) - **(1 lecture).**
Idea of Algorithm: steps to solve logical and numerical problems. Representation of Algorithm: Flowchart/Pseudocode with examples. **(1 lecture)**
From algorithms to programs; source code, variables (with data types) variables and memory locations, Syntax and Logical Errors in compilation, object and executable code- **(2 lectures)**

Unit 2:Arithmetic expressions and precedence **(2 lectures)**

Unit 2: Conditional Branching and Loops **(6 lectures)**

Writing and evaluation of conditionals and consequent branching **(3 lectures)**
Iteration and loops **(3 lectures)**

Unit 3Arrays **(6 lectures)**

Arrays (1-D, 2-D), Character arrays and Strings

Unit 4Basic Algorithms **(6 lectures)**

Searching, Basic Sorting Algorithms (Bubble, Insertion and Selection), Finding roots of equations, notion of order of complexity through example programs (no formal definition required)

Unit 5Function **(5 lectures)**

Functions (including using built in libraries), Parameter passing in functions, call by value, Passing arrays to functions: idea of call by reference

Unit 6Recursion **(4 -5 lectures)**

Recursion, as a different way of solving problems. Example programs, such as Finding Factorial, Fibonacci series, Ackerman function etc. Quick sort or Merge sort.

Unit 7Structure **(4 lectures)**

Structures, Defining structures and Array of Structures

Unit 8Pointers **(2 lectures)**

Idea of pointers, Defining pointers, Use of Pointers in self-referential structures, notion of linked list (no implementation)

Unit 9File handling (only if time is available, otherwise should be done as part of the lab)

Suggested Text Books

(i) Byron Gottfried, Schaum's Outline of Programming with C, McGraw-Hill
(ii) E. Balaguruswamy, Programming in ANSI C, Tata McGraw-Hill

Suggested Reference Books

(i) Brian W. Kernighan and Dennis M. Ritchie, The C Programming Language, Prentice Hall of India

Course Outcomes

The student will learn

- To formulate simple algorithms for arithmetic and logical problems.
- To translate the algorithms to programs (in C language).
- To test and execute the programs and correct syntax and logical errors.

- To implement conditional branching, iteration and recursion.
- To decompose a problem into functions and synthesize a complete program using divide and conquer approach.
- To use arrays, pointers and structures to formulate algorithms and programs.
- To apply programming to solve matrix addition and multiplication problems and searching and sorting problems.
- To apply programming to solve simple numerical method problems, namely rot finding of function, differentiation of function and simple integration.

(ii)Laboratory - Programming for Problem Solving[L : 0; T:0 ; P : 4 (2credits)]

[The laboratory should be preceded or followed by a tutorial to explain the approach or algorithm to be implemented for the problem given.]

Tutorial 1: Problem solving using computers:
Lab1: Familiarization with programming environment

Tutorial 2: Variable types and type conversions:
Lab 2: Simple computational problems using arithmetic expressions

Tutorial 3: Branching and logical expressions:
Lab 3: Problems involving if-then-else structures

Tutorial 4: Loops, while and for loops:
Lab 4: Iterative problems e.g., sum of series

Tutorial 5: 1D Arrays: searching, sorting:
Lab 5: 1D Array manipulation

Tutorial 6: 2D arrays and Strings
Lab 6: Matrix problems, String operations

Tutorial 7: Functions, call by value:
Lab 7: Simple functions

Tutorial 8 &9: Numerical methods (Root finding, numerical differentiation, numerical integration):
Lab 8 and 9: Programming for solving Numerical methods problems

Tutorial 10: Recursion, structure of recursive calls
Lab 10: Recursive functions

Tutorial 11: Pointers, structures and dynamic memory allocation
Lab 11: Pointers and structures

Tutorial 12: File handling:
Lab 12: File operations

Laboratory Outcomes

- To formulate the algorithms for simple problems
- To translate given algorithms to a working and correct program
- To be able to correct syntax errors as reported by the compilers
- To be able to identify and correct logical errors encountered at run time

- To be able to write iterative as well as recursive programs
- To be able to represent data in arrays, strings and structures and manipulate them through a program
- To be able to declare pointers of different types and use them in defining self-referential structures.
- To be able to create, read and write to and from simple text files.

Course code	HSMC 101				
Category	Humanities and Social Sciences including Management courses				
Course title	**English**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	Semester - II
	2	**0**	**2**	**3**	
Pre-requisites (if any)	-				

English

Detailed contents

1. Vocabulary Building

1.1 The concept of Word Formation
1.2 Root words from foreign languages and their use in English
1.3 Acquaintance with prefixes and suffixes from foreign languages in English to form derivatives.
1.4 Synonyms, antonyms, and standard abbreviations.

2. Basic Writing Skills

2.1 Sentence Structures
2.2 Use of phrases and clauses in sentences
2.3 Importance of proper punctuation
2.4 Creating coherence
2.5 Organizing principles of paragraphs in documents
2.6 Techniques for writing precisely

3. Identifying Common Errors in Writing

3.1 Subject-verb agreement
3.2 Noun-pronoun agreement
3.3 Misplaced modifiers
3.4 Articles
3.5 Prepositions
3.6 Redundancies
3.7 Clichés

4. Nature and Style of sensible Writing

4.1 Describing
4.2 Defining
4.3 Classifying
4.4 Providing examples or evidence
4.5 Writing introduction and conclusion

5. Writing Practices
5.1 Comprehension
5.2 Précis Writing
5.3 Essay Writing

6. Oral Communication
(This unit involves interactive practice sessions in Language Lab)
- Listening Comprehension
- Pronunciation, Intonation, Stress and Rhythm
- Common Everyday Situations: Conversations and Dialogues
- Communication at Workplace
- Interviews
- Formal Presentations

Suggested Readings:
(i) *Practical English Usage.* Michael Swan. OUP. 1995.
(ii) *Remedial English Grammar.* F.T. Wood. Macmillan.2007
(iii)*On Writing Well.* William Zinsser. Harper Resource Book. 2001
(iv)*Study Writing.* Liz Hamp-Lyons and Ben Heasly. Cambridge University Press. 2006.
(v) *Communication Skills.* Sanjay Kumar and PushpLata. Oxford University Press. 2011.
(vi)*Exercises in Spoken English.* Parts. I-III. CIEFL, Hyderabad. Oxford University Press

Course Outcomes
The student will acquire basic proficiency in English including reading and listening comprehension, writing and speaking skills.

Course code	ESC 102				
Category	Engineering Science Courses				
Course title	**Engineering Graphics & Design (Theory & Lab.)**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	Semester - I
	1	**0**	**4**	**3**	
Pre-requisites (if any)	-				

Engineering Graphics & Design **[A total of 10 lecture hours & 60 hours of lab.]**

[[L : 1; T:0; P : 4 (3 credits)]

Detailed contents

Traditional Engineering Graphics:
Principles of Engineering Graphics; Orthographic Projection; Descriptive Geometry; Drawing Principles; Isometric Projection; Surface Development; Perspective; Reading a Drawing; Sectional Views; Dimensioning & Tolerances; True Length, Angle; intersection, Shortest Distance.

Computer Graphics:
Engineering Graphics Software; -Spatial Transformations; Orthographic Projections; Model Viewing; Co-ordinate Systems; Multi-view Projection; Exploded Assembly; Model Viewing; Animation; Spatial Manipulation; Surface Modelling; Solid Modelling; Introduction to Building Information Modelling (BIM)

(Except the basic essential concepts, most of the teaching part can happen concurrently in the laboratory)

Module 1: Introduction to Engineering Drawingcovering,
Principles of Engineering Graphics and their significance, usage of Drawing instruments, lettering, Conic sections including the Rectangular Hyperbola (General method only); Cycloid, Epicycloid, Hypocycloid and Involute; Scales – Plain, Diagonal and Vernier Scales;

Module 2: Orthographic Projectionscovering,
Principles of Orthographic Projections-Conventions - Projections of Points and lines inclined to both planes; Projections of planes inclined Planes - Auxiliary Planes;

Module 3: Projections of Regular Solidscovering,
those inclined to both the Planes- Auxiliary Views; Draw simple annotation, dimensioning and scale. Floor plans that include: windows, doors, and fixtures such as WC, bath, sink, shower, etc.

Module 4:Sections and Sectional Views of Right Angular Solidscovering,
Prism, Cylinder, Pyramid, Cone – Auxiliary Views; Development of surfaces of Right Regular Solids - Prism, Pyramid, Cylinder and Cone; Draw the sectional orthographic views of geometrical solids, objects from industry and dwellings (foundation to slab only)

***Module 5: Isometric Projections* covering,**
Principles of Isometric projection – Isometric Scale, Isometric Views, Conventions; Isometric Views of lines, Planes, Simple and compound Solids; Conversion of Isometric Views to Orthographic Views and Vice-versa, Conventions;

Module 6: Overview of Computer Graphicscovering,
listing the computer technologies that impact on graphical communication, Demonstrating knowledge of the theory of CAD software [such as: The Menu System, Toolbars (Standard, Object Properties, Draw, Modify and Dimension), Drawing Area (Background, Crosshairs, Coordinate System), Dialog boxes and windows, Shortcut menus (Button Bars), The Command Line (where applicable), The Status Bar, Different methods of zoom as used in CAD, Select and erase objects.; Isometric Views of lines, Planes, Simple and compound Solids];

Module 7: Customisation& CAD Drawing
consisting of set up of the drawing page and the printer, including scale settings, Setting up of units and drawing limits; ISO and ANSI standards for coordinate dimensioning and tolerancing; Orthographic constraints, Snap to objects manually and automatically; Producing drawings by using various coordinate input entry methods to draw straight lines, Applying various ways of drawing circles;

Module 8: Annotations, layering & other functionscovering
applying dimensions to objects, applying annotations to drawings; Setting up and use of

Layers, layers to create drawings, Create, edit and use customized layers; Changing line lengths through modifying existing lines (extend/lengthen); Printing documents to paper using the print command; orthographic projection techniques; Drawing sectional views of composite right regular geometric solids and project the true shape of the sectioned surface; Drawing annotation, Computer-aided design (CAD) software modeling of parts and assemblies. Parametric and non-parametric solid, surface, and wireframe models. Part editing and two-dimensional documentation of models. Planar projection theory, including sketching of perspective, isometric, multiview, auxiliary, and section views. Spatial visualization exercises. Dimensioning guidelines, tolerancing techniques; dimensioning and scale multi views of dwelling;

Module 9: Demonstration of a simple team design project *that illustrates*
Geometry and topology of engineered components: creation of engineering models and their presentation in standard 2D blueprint form and as 3D wire-frame and shaded solids; meshed topologies for engineering analysis and tool-path generation for component manufacture; geometric dimensioning and tolerancing; Use of solid-modeling software for creating associative models at the component and assembly levels; floor plans that include: windows, doors, and fixtures such as WC, bath, sink, shower, etc. Applying colour coding according to building drawing practice; Drawing sectional elevation showing foundation to ceiling; Introduction to Building Information Modelling (BIM).

Suggested Text/Reference Books:

(i) Bhatt N.D., Panchal V.M. & Ingle P.R., (2014), Engineering Drawing, Charotar Publishing House
(ii) Shah, M.B. & Rana B.C. (2008), Engineering Drawing and Computer Graphics, Pearson Education
(iii) Agrawal B. & Agrawal C. M. (2012), Engineering Graphics, TMH Publication
(iv) Narayana, K.L. & P Kannaiah (2008), Text book on Engineering Drawing, Scitech Publishers
(v) (Corresponding set of) CAD Software Theory and User Manuals

Course Outcomes

All phases of manufacturing or construction require the conversion of new ideas and design concepts into the basic line language of graphics. Therefore, there are many areas (civil, mechanical, electrical, architectural and industrial) in which the skills of the CAD technicians play major roles in the design and development of new products or construction. Students prepare for actual work situations through practical training in a new state-of-the-art computer designed CAD laboratory using engineering software. This course is designed to address:

- to prepare you to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- to prepare you to communicate effectively
- to prepare you to use the techniques, skills, and modern engineering tools necessary for engineering practice

The student will learn :

- Introduction to engineering design and its place in society
- Exposure to the visual aspects of engineering design
- Exposure to engineering graphics standards
- Exposure to solid modelling

- Exposure to computer-aided geometric design
- Exposure to creating working drawings
- Exposure to engineering communication

Course code	ESC 104				
Category	Engineering Science Courses				
Course title	**Workshop/Manufacturing Practices (Theory & Lab.)**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	Semester-II
	1	**0**	**4**	**3**	
Pre-requisites (if any)	**-**				

Workshop/Manufacturing Practices[[L : 1; T:0; P : 0 (1 credit)]

Lectures & videos: (10 hours)

Detailed contents

1. Manufacturing Methods- casting, forming, machining, joining, advanced manufacturing methods **(3 lectures)**
2. CNC machining, Additive manufacturing **(1 lecture)**
3. Fitting operations & power tools **(1 lecture)**
4. Electrical &Electronics **(1 lecture)**
5. Carpentry **(1 lecture)**
6. Plastic moulding, glass cutting **(1 lecture)**
7. Metal casting **(1 lecture)**
8. Welding (arc welding & gas welding), brazing **(1 lecture)**

Suggested Text/Reference Books:

(i) Hajra Choudhury S.K., Hajra Choudhury A.K. and Nirjhar Roy S.K., “Elements of Workshop Technology”, Vol. I 2008 and Vol. II 2010, Media promoters and publishers private limited, Mumbai.

(ii) Kalpakjian S. And Steven S. Schmid, “Manufacturing Engineering and Technology”, 4th edition, Pearson Education India Edition, 2002.

(iii)Gowri P. Hariharan and A. Suresh Babu,”Manufacturing Technology – I” Pearson Education, 2008.

(iv)Roy A. Lindberg, “Processes and Materials of Manufacture”, 4th edition, Prentice Hall India, 1998.

(v) Rao P.N., “Manufacturing Technology”, Vol. I and Vol. II, Tata McGrawHill House, 2017.

Course Outcomes

Upon completion of this course, the students will gain knowledge of the different manufacturing processes which are commonly employed in the industry, to fabricate components using different materials.

(ii) Workshop Practice:(60 hours)[L : 0; T:0 ; P : 4 (2 credits)]

1. Machine shop **(10 hours)**
2. Fitting shop **(8 hours)**
3. Carpentry **(6 hours)**
4. Electrical & Electronics**(8 hours)**
5. Welding shop **(8 hours (Arc welding 4 hrs + gas welding 4 hrs)**
6. Casting **(8 hours)**
7. Smithy **(6 hours)**
8. Plastic moulding& Glass Cutting (6 hours)

Examinations could involve the actual fabrication of simple components, utilizing one or more of the techniques covered above.

Laboratory Outcomes

- Upon completion of this laboratory course, students will be able to fabricate components with their own hands.
- They will also get practical knowledge of the dimensional accuracies and dimensional tolerances possible with different manufacturing processes.
- By assembling different components, they will be able to produce small devices of their interest.

<table>
<tr><td>Course code</td><td colspan="5">ESC 101</td></tr>
<tr><td>Category</td><td colspan="5">Engineering Science Course</td></tr>
<tr><td>Course title</td><td colspan="5">Basic Electrical Engineering (Theory & Lab.)</td></tr>
<tr><td rowspan="2">Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td rowspan="2">Semester –I</td></tr>
<tr><td>3</td><td>1</td><td>2</td><td>5</td></tr>
<tr><td>Pre-requisites (if any)</td><td colspan="5">-</td></tr>
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(i)Basic Electrical Engineering [L : 3; T:1; P : 0 (4 credits)]

Detailed contents :

Module 1 : DC Circuits (8 hours)

Electrical circuit elements (R, L and C), voltage and current sources, Kirchoff current and voltage laws, analysis of simple circuits with dc excitation. Superposition, Thevenin and Norton Theorems. Time-domain analysis of first-order RL and RC circuits.

Module 2: AC Circuits (8 hours)

Representation of sinusoidal waveforms, peak and rms values, phasor representation, real power, reactive power, apparent power, power factor. Analysis of single-phase ac circuits consisting of R, L, C, RL, RC, RLC combinations (series and parallel), resonance. Three-phase balanced circuits, voltage and current relations in star and delta connections.

Module 3: Transformers (6 hours)

Magnetic materials, BH characteristics, ideal and practical transformer, equivalent circuit, losses in transformers, regulation and efficiency. Auto-transformer and three-phase transformer connections.

Module 4: Electrical Machines (8 hours)

Generation of rotating magnetic fields, Construction and working of a three-phase induction motor, Significance of torque-slip characteristic. Loss components and efficiency, starting and speed control of induction motor. Single-phase induction motor. Construction, working, torque-speed characteristic and speed control of separately excited dc motor. Construction and working of synchronous generators.

Module 5: Power Converters (6 hours)

DC-DC buck and boost converters, duty ratio control. Single-phase and three-phase voltage source inverters; sinusoidal modulation.

Module 6: Electrical Installations (6 hours)

Components of LT Switchgear: Switch Fuse Unit (SFU), MCB, ELCB, MCCB, Types of Wires and Cables, Earthing. Types of Batteries, Important Characteristics for Batteries. Elementary calculations for energy consumption, power factor improvement and battery backup.

Suggested Text / Reference Books

(i) D. P. Kothari and I. J. Nagrath, “Basic Electrical Engineering”, Tata McGraw Hill, 2010.
(ii) D. C. Kulshreshtha, “Basic Electrical Engineering”, McGraw Hill, 2009.
(iii)L. S. Bobrow, “Fundamentals of Electrical Engineering”, Oxford University Press, 2011.
(iv)E. Hughes, “Electrical and Electronics Technology”, Pearson, 2010.
(v) V. D. Toro, “Electrical Engineering Fundamentals”, Prentice Hall India, 1989.

Course Outcomes

- To understand and analyze basic electric and magnetic circuits
- To study the working principles of electrical machines and power converters.
- To introduce the components of low voltage electrical installations

(ii)Basic Electrical Engineering Laboratory [L : 0; T:0 ; P : 2 (1 credit)]

List of experiments/demonstrations:

- Basic safety precautions. Introduction and use of measuring instruments – voltmeter, ammeter, multi-meter, oscilloscope. Real-life resistors, capacitors and inductors.
- Measuring the steady-state and transient time-response of R-L, R-C, and R-L-C circuits to a step change in voltage (transient may be observed on a storage oscilloscope). Sinusoidal steady state response of R-L, and R-C circuits – impedance calculation and verification. Observation of phase differences between current and voltage. Resonance in R-L-C circuits.
- Transformers: Observation of the no-load current waveform on an oscilloscope (non-sinusoidal wave-shape due to B-H curve nonlinearity should be shown along with a discussion about harmonics). Loading of a transformer: measurement of primary and secondary voltages and currents, and power.
- Three-phase transformers: Star and Delta connections. Voltage and Current relationships (line-line voltage, phase-to-neutral voltage, line and phase currents). Phase-shifts between the primary and secondary side. Cumulative three-phase power in balanced three-phase circuits.
- Demonstration of cut-out sections of machines: dc machine (commutator-brush arrangement), induction machine (squirrel cage rotor), synchronous machine (field

winging - slip ring arrangement) and single-phase induction machine.
- Torque Speed Characteristic of separately excited dc motor.
- Synchronous speed of two and four-pole, three-phase induction motors. Direction reversal by change of phase-sequence of connections. Torque-Slip Characteristic of an induction motor. Generator operation of an induction machine driven at super-synchronous speed.
- Synchronous Machine operating as a generator: stand-alone operation with a load. Control of voltage through field excitation.
- Demonstration of (a) dc-dc converters (b) dc-ac converters – PWM waveform (c) the use of dc-ac converter for speed control of an induction motor and (d) Components of LT switchgear.

Laboratory Outcomes
- Get an exposure to common electrical components and their ratings.
- Make electrical connections by wires of appropriate ratings.
- Understand the usage of common electrical measuring instruments.
- Understand the basic characteristics of transformers and electrical machines.
- Get an exposure to the working of power electronic converters.

A Guide to Induction Program

1 Introduction

(Induction Program was discussed and approved for all colleges by AICTE in March 2017. It was discussed and accepted by the Council of IITs for all IITs in August 2016. It was originally proposed by a Committee of IIT Directors and accepted at the meeting of all IIT Directors in March 2016.[1] *This guide has been prepared based on the Report of the Committee of IIT Directors and the experience gained through its pilot implementation in July 2016 as accepted by the Council of IITs. Purpose of this document is to help institutions in understanding the spirit of the accepted Induction Program and implementing it.)*

Engineering colleges were established to train graduates well in the branch/department of admission, have a holistic outlook, and have a desire to work for national needs and beyond.

The graduating student must have knowledge and skills in the area of his study. However, he must also have broad understanding of society and relationships. Character needs to be nurtured as an essential quality by which he would understand and fulfill his responsibility as an engineer, a citizen and a human being. Besides the above, several meta-skills and underlying values are needed.

There is a mad rush for engineering today, without the student determining for himself his interests and his goals. This is a major factor in the current state of demotivation towards studies that exists among UG students.

The success of gaining admission into a desired institution but failure in getting the desired branch, with peer pressure generating its own problems, leads to a peer environment that is demotivating and corrosive. Start of hostel life without close parental supervision at the same time, further worsens it with also a poor daily routine.

To come out of this situation, a multi-pronged approach is needed. One will have to work closely with the newly joined students in making them feel comfortable, allow them to explore their academic interests and activities, reduce competition and make them work for excellence, promote bonding within them, build relations between teachers and students, give a broader view of life, and build character.

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[1] A Committee of IIT Directors was setup in the 152nd Meeting of IIT Directors on 6th September 2015 at IIT Patna, on how to motivate undergraduate students at IITs towards studies, and to develop verbal ability. The Committee submitted its report on 19th January 2016. It was considered at the 153rd Meeting of all IIT Directors at IIT Mandi on 26 March 2016, and the accepted report came out on 31 March 2016. The Induction Program was an important recommendation, and its pilot was implemented by three IITs, namely, IIT(BHU), IIT Mandi and IIT Patna in July 2016. At the 50th meeting of the Council of IITs on 23 August 2016, recommendation on the Induction Program and the report of its pilot implementation were discussed and the program was accepted for all IITs.

2 Induction Program

When new students enter an institution, they come with diverse thoughts, backgrounds and preparations. It is important to help them adjust to the new environment and inculcate in them the ethos of the institution with a sense of larger purpose. Precious little is done by most of the institutions, except for an orientation program lasting a couple of days.

We propose a 3-week long induction program for the UG students entering the institution, right at the start. Normal classes start only after the induction program is over. Its purpose is to make the students feel comfortable in their new environment, open them up, set a healthy daily routine, create bonding in the batch as well as between faculty and students, develop awarness, sensitivity and understanding of the self, people around them, society at large, and nature.[2]

The time during the Induction Program is also used to rectify some critical lacunas, for example, English background, for those students who have deficiency in it.

The following are the activities under the induction program in which the student would be fully engaged throughout the day for the entire duration of the program.

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[2] Induction Program as described here borrows from three programs running earlier at different institutions: (1) Foundation Program running at IIT Gadhinagar since July 2011, (2) Human Values course running at IIIT Hyderabad since July 2005, and (3) Counselling Service or mentorship running at several IITs for many decades. Contribution of each one is described next.

(1) IIT Gandhinagar was the first IIT to recognize and implement a special 5-week Foundation Program for the incoming 1st year UG students. It took a bold step that the normal classes would start only after the five week period. It involved activities such as games, art, etc., and also science and other creative workshops and lectures by resource persons from outside.

(2) IIIT Hyderabad was the first one to implement a compulsary course on Human Values. Under it, classes were held by faculty through discussions in small groups of students, rather than in lecture mode. Moreover, faculty from all departments got involved in conducting the group discussions under the course. The content is non-sectarian, and the mode is dialogical rather than sermonising or lecturing. Faculty were trained beforehand, to conduct these discussions and to guide students on issues of life.

(3) Counselling at some of the IITs involves setting up mentor-mentee network under which 1st year students would be divided into small groups, each assigned a senior student as a student guide, and a faculty member as a mentor. Thus, a new student gets connected to a faculty member as well as a senior student, to whom he/she could go to in case of any difficulty whether psychological, financial, academic, or otherwise.

The Induction Program defined here amalgamates all the three into an integrated whole, which leads to its high effectiveness in terms of building physical activity, creativity, bonding, and character. It develops sensitivity towards self and one's relationships, builds awareness about others and society beyond the individual, and also in bonding with their own batch-mates and a senior student besides a faculty member.

Scaling up the above amalgamation to an intake batch of 1000 plus students was done at IIT(BHU), Varanasi starting from July 2016.

2.1 Physical Activity

This would involve a daily routine of physical activity with games and sports. It would start with all students coming to the field at 6 am for light physical exercise or yoga. There would also be games in the evening or at other suitable times according to the local climate. These would help develop team work. Each student should pick one game and learn it for three weeks. There could also be gardening or other suitably designed activity where labour yields fruits from nature.

2.2 Creative Arts

Every student would chose one skill related to the arts whether visual arts or performing arts. Examples are painting, sculpture, pottery, music, dance etc. The student would pursue it everyday for the duration of the program.

These would allow for creative expression. It would develop a sense of aesthetics and also enhance creativity which would, hopefully, flow into engineering design later.

2.3 Universal Human Values

It gets the student to explore oneself and allows one to experience the joy of learning, stand up to peer pressure, take decisions with courage, be aware of relationships with colleagues and supporting staff in the hostel and department, be sensitive to others, etc. Need for character building has been underlined earlier. A module in Universal Human Values provides the base.

Methodology of teaching this content is extremely important. It must not be through do's and dont's, but get students to explore and think by engaging them in a dialogue. It is best taught through group discussions and real life activities rather than lecturing. The role of group discussions, however, with clarity of thought of the teachers cannot be over emphasized. It is essential for giving exposure, guiding thoughts, and realizing values.

The teachers must come from all the departments rather than only one department like HSS or from outside of the Institute. Experiments in this direction at IIT(BHU) are noteworthy and one can learn from them.[3]

Discussions would be conducted in small groups of about 20 students with a faculty mentor each. It is to open thinking towards the self. Universal Human Values discussions could even continue for rest of the semester as a normal course, and not stop with the induction program.

Besides drawing the attention of the student to larger issues of life, it would build relationships between teachers and students which last for their entire 4-year stay and possibly beyond.

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[3] The Universal Human Values Course is a result of a long series of experiments at educational institutes starting from IIT-Delhi and IIT Kanpur in the 1980s and 1990s as an elective course, NIT Raipur in late 1990s as a compulsory one-week off campus program. The courses at IIT(BHU) which started from July 2014, are taken and developed from two compulsory courses at IIIT Hyderabad first introduced in July 2005.

2.4 Literary

Literary activity would encompass reading, writing and possibly, debating, enacting a play etc.

2.5 Proficiency Modules

This period can be used to overcome some critical lacunas that students might have, for example, English, computer familiarity etc. These should run like crash courses, so that when normal courses start after the induction program, the student has overcome the lacunas substantially. We hope that problems arising due to lack of English skills, wherein students start lagging behind or failing in several subjects, for no fault of theirs, would, hopefully, become a thing of the past.

2.6 Lectures by Eminent People

This period can be utilized for lectures by eminent people, say, once a week. It would give the students exposure to people who are socially active or in public life.

2.7 Visits to Local Area

A couple of visits to the landmarks of the city, or a hospital or orphanage could be organized. This would familiarize them with the area as well as expose them to the under privileged.

2.8 Familiarization to Dept./Branch & Innovations

The students should be told about different method of study compared to coaching that is needed at IITs. They should be told about what getting into a branch or department means what role it plays in society, through its technology. They should also be shown the laboratories, workshops & other facilties.

3 Schedule

The activities during the Induction Program would have an Initial Phase, a Regular Phase and a Closing Phase. The Initial and Closing Phases would be two days each.

3.1 Initial Phase

Time	Activity
Day 0	
Whole day	*Students arrive - Hostel allotment. (Preferably do pre-allotment)*
Day 1	
09:00 am - 03:00 pm	*Academic registration*
04:30 pm - 06:00 pm	Orientation
Day 2	
09:00 am - 10:00 am	Diagnostic test (for English etc.)
10:15 am - 12:25 pm	Visit to respective depts.
12:30 pm - 01:55 pm	*Lunch*
02:00 pm - 02:55 pm	Director's address
03:00 pm - 05:00 pm	Interaction with parents
03:30 pm - 05:00 pm	Mentor-mentee groups - Introduction within group. (Same as Universal Human Values groups)

3.2 Regular Phase

After two days is the start of the Regular Phase of induction. With this phase there would be regular program to be followed every day.

3.2.1 Daily Schedule

Some of the activities are on a daily basis, while some others are at specified periods within the Induction Program. We first show a typical daily timetable.

Sessn.	*Time*	*Activity*	*Remarks*
	Day 3 onwards		
	06:00 am	*Wake up call*	
I	06:30 am - 07:10 am	Physical activity (mild exercise/yoga)	
	07:15 am - 08:55 am	*Bath, Breakfast, etc.*	
II	09:00 am - 10:55 am	Creative Arts / Universal Human Values	Half the groups do Creative Arts
III	11:00 am - 12:55 pm	Universal Human Values / Creative Arts	Complementary alternate
	01:00 pm - 02:25 pm	*Lunch*	
IV	02:30 pm - 03:55 pm	Afternoon Session	See below.
V	04:00 pm - 05:00 pm	Afternoon Session	See below.
	05:00 pm - 05:25 pm	*Break / light tea*	
VI	05:30 pm - 06:45 pm	Games / Special Lectures	
	06:50 pm - 08:25 pm	*Rest and Dinner*	
VII	08:30 pm - 09:25 pm	Informal interactions (in hostels)	

Sundays are off. Saturdays have the same schedule as above or have outings.

3.2.2 Afternoon Activities (Non-Daily)

The following five activities are scheduled at different times of the Induction Program, and are not held daily for everyone:

1. Familiarization to Dept./Branch & Innovations
2. Visits to Local Area
3. Lectures by Eminent People
4. Literary
5. Proficiency Modules

Here is the approximate activity schedule for the afternoons (may be changed to suit local needs):

Activity	*Session*	*Remarks*
Familiarization with Dept/Branch & Innovations	IV	For 3 days (Day 3 to 5)
Visits to Local Area	IV, V and VI	For 3 days - interspersed (e.g., 3 Saturdays)
Lectures by Eminent People	IV	As scheduled - 3-5 lectures
Literary (Play / Book Reading / Lecture)	IV	For 3-5 days
Proficiency Modules	V	Daily, but only for those who need it

3.3 Closing Phase

Time	*Activity*
Last But One Day	
08:30 am - 12 noon	Discussions and finalization of presentation within each group
02:00 am - 05:00 pm	Presentation by each group in front of 4 other groups besides their own (about 100 students)
Last Day	
Whole day	Examinations (if any). May be expanded to last 2 days, in case needed.

3.4 Follow Up after Closure

A question comes up as to what would be the follow up program after the formal 3-week Induction Program is over? The groups which are formed should function as mentor-mentee network. A student should feel free to approach his faculty mentor or the student guide, when facing any kind of problem, whether academic or financial or psychological etc. (For every 10 undergraduate first year students, there would be a senior student as a *student guide*, and for every 20 students, there would be a *faculty mentor*.) Such a group should remain for the entire 4-5 year duration of the stay of the student. Therefore, it would be good to have groups with the students as well as teachers from the same department/discipline[4].

Here we list some important suggestions which have come up and which have been experimented with.

3.4.1 Follow Up after Closure – Same Semester

It is suggested that the groups meet with their faculty mentors once a month, within the semester after the 3-week Induction Program is over. This should be a scheduled meeting shown in the timetable. (The groups are of course free to meet together on their own more often, for the student groups to be invited to their faculty mentor's home for dinner or tea, nature walk, etc.)

3.4.2 Follow Up – Subsequent Semesters

It is extremely important that continuity be maintained in subsequent semesters.

It is suggested that at the start of the subsequent semesters (upto fourth semester), three days be set aside for three full days of activities related to follow up to Induction Program. The students be shown inspiring films, do collective art work, and group discussions be conducted. Subsequently, the groups should meet at least once a month.

4 Summary

Engineering institutions were set up to generate well trained manpower in engineering with a feeling of responsibility towards oneself, one's family, and society. The incoming undergraduate students are driven by their parents and society to join engineering without understanding their own interests and talents. As a result, most students fail to link up with the goals of their own institution.

The graduating student must have values as a human being, and knowledge and meta-skills related to his/her profession as an engineer and as a citizen. Most students who get demotivated to study engineering or their branch, also lose interest in learning.

The *Induction Program* is designed to make the newly joined students feel comfortable, sensitize them towards exploring their academic interests and activities, reducing competition and making them work for excellence, promote bonding within them, build relations between teachers and students, give a broader view of life, and building of character.

The *Universal Human Values* component, which acts as an anchor, develops awareness and sensitivity, feeling of equality, compassion and oneness, draw attention to society and nature, and character to follow through. It also makes them reflect on their relationship with their families and extended family in the college (with hostel staff and others). It also connects students with each other and with teachers so that they can share any difficulty they might be facing and seek help.

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[4] We are aware that there are advantages in mixing the students from different depts. However, in mixing, it is our experience that the continuity of the group together with the faculty mentor breaks down soon after. Therefore, the groups be from the same dept. but hostel wings have the mixed students from different depts. For example, the hostel room allotment should be in alphabetical order irrespective of dept.

References:

Motivating UG Students Towards Studies,
Rajeev Sangal, IITBHU Varanasi, Gautam Biswas, IIT Guwahati, Timothy Gonsalves, IIT Mandi, Pushpak Bhattacharya, IIT Patna, (Committee of IIT Directors),
31 March 2016, IIT Directors' Secretariat, IIT Delhi.

Contact:

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18 June 2017

MODEL CURRICULUM

for

UNDERGRADUATE DEGREE COURSES
IN

CIVIL ENGINEERING

(Engineering & Technology)

[January 2018]

ALL INDIA COUNCIL FOR TECHNICAL EDUCATION
Nelson Mandela Marg, Vasant Kunj, New Delhi 110 070
www.aicte-india.org

All India Council for Technical Education
Model curriculum for
Undergraduate Degree Courses in Engineering & Technology

CIVIL ENGINEERING

CONTENTS

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3	3	**Detailed 4-year Curriculum Contents**
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		HSMC201: Effective Technical Communication
		HSMC251: Introduction to Civil Engineering
		HSMC252: Civil Engineering – Societal & Global Impact
		HSMC255: Professional Practice, Law & Ethics
	3.2	**Basic Science Courses**
		BSC101: Physics (Mechanics & Mechanics of Solids)
		BSC102 Chemistry-I
		BSC109: Biology-I (Biology for Engineers)
		BSC103: Mathematics-I (Calculus, Multivariable Calculus & Linear Algebra)
		BSC104: Mathematics-II (Differential equations)
		BSC201: Mathematics-III (Transform & Discrete Mathematics)
		BSC225: Life Science
	3.3	**Engineering Science Courses**
		ESC101: Basic Electrical Engineering
		ESC102: Programming for Problem Solving
		ESC104: Workshop / Manufacturing Practices
		ESC105: Engineering Graphics & Design
		ESC202: Basic Electronics
		ESC203: Computer-aided Civil Engineering Drawing
		ESC205: Engineering Mechanics
		ESC209: Mechanical Engineering
		ESC212: Energy Science & Engineering
	3.4	**Professional Core Courses/Fundamental Engineering Principles & Tools**
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		PCC-CE202: Engineering Geology

Sl. No.	**Chapter**	**Title**
		PCC-CE203: Disaster Preparedness & Planning Management
		PCC-CE204: Introduction to Fluid Mechanics
		PCC-CE205: Introduction to Solid Mechanics
		PCC-CE206: Surveying and Geomatics
		PCC-CE207: Materials, Testing & Evaluation
		PCC-CE301: Mechanics of Materials
		PCC-CE302: Hydraulic Engineering
		PCC-CE303: Structural Engineering
		PCC-CE304: Geotechnical Engineering
		PCC-CE305: Hydrology and Water Resources Engineering
		PCC-CE306: Environmental Engineering
		PCC-CE307: Transportation Engineering
		PCC-CE308: Construction Engineering & Management
		PCC-CE309: Engineering Economy, Estimation & Costing
4	**ANNEXURE-I**	SYLLABUS FOR BASKET OF ELECTIVE COURSES OF ELECTED TRACKS
5	**APPENDIX-A**	A GUIDE TO INDUCTION PROGRAM
6		MC :Model Curriculum for Mandatory Non-credit courses
7		HSMC: Model Curriculum for courses in Humanities and Social Sciences including Management
8		Virtual Laboratories for various disciplines

All India Council for Technical Education
Model curriculum for
Undergraduate Degree Courses in Engineering & Technology

CIVIL ENGINEERING

Chapter -1

General, Course structure & Theme
&
Semester-wise credit distribution

A. Definition of Credit:

1 Hr. Lecture (L) per week	1 credit
1 Hr. Tutorial (T) per week	1 credit
1 Hr. Practical (P) per week	0.5 credits
2 Hours Practical (Lab) per week	1 credit

B. Range of credits -A range of credits from 150 to 160 for a student to be eligible to get Under Graduate degree in Engineering. A student will be eligible to get Under Graduate degree with Honours or additional Minor Engineering, if he/she completes an additional 20 credits. These could be acquired through MOOCs.

C. Structure of Undergraduate Engineering program:

S. No.	Category	Breakup of Credits (Total 160)
1	Humanities and Social Sciences including Management courses	12
2	Basic Science Courses	26
3	Engineering Science courses including workshop, drawing, basics of electrical/mechanical/computer etc.	29
4	Professional core courses	47
5	Professional Elective courses relevant to chosen specialization/branch	23
6	Open subjects – Electives from other technical and /or emerging subjects	11
7	Project work, seminar and internship in industry or appropriate work place/ academic and research institutions in India/abroad	12
8	Mandatory Courses [Environmental Sciences, Induction program, Indian Constitution, Essence of Indian Traditional Knowledge]	(non-credit)
	Total	160*

**Minor variation is allowed as per need of the respective disciplines.*

D. Credit distribution in the First year of Undergraduate Engineering program :

Subject	Lecture (L)	Tutorial (T)	Laboratory/ Practical (P)	Total Credits (C)
Chemistry-I	3	1	3	5.5
Physics	3	1	3	5.5
Mathematics-I	3	1	0	4
Mathematics-II	3	1	0	4
Programming for Problem Solving	3	0	4	5
English	2	0	2	3
Engineering Graphics & Design	1	0	4	3
Workshop/ Practicals	1	0	4	3
Basic Electrical Engineering	3	1	2	5
*Biology	2	1	0	3
*Engineering Mechanics	3	1	0	4
* Mathematics-III	2	0	0	2

*****_These courses may be offered preferably in the 3rd semester & onwards._

E. Course Code and Definition:

Course code	Definitions
BSC	Basic Science Courses
ESC	Engineering Science Courses
HSMC	Humanities and Social Sciences including Management courses
PCC-CE	Professional core courses
PEC-CE	Professional Elective courses
OEC-CE	Open Elective courses
LC-CE	Laboratory course
MC	Mandatory courses
PROJ-CE	Project

HUMANITIES & SOCIAL SCIENCES INCLUDING MANAGEMENT

Sl. No	Code No.	Subject	Semester	Credits
1.	HSMC101	English	II	3
2.	HSMC251	Introduction to Civil Engineering	III	2
3.	HSMC201	Humanities-I (Effective Technical Communication)	III	3
4.	HSMC252	Civil Engineering - Societal & Global Impact	IV	2
5.	HSMC255	Professional Practice, Law & Ethics	V	2
			Total Credits:	**12**

BASIC SCIENCE COURSES

Sl. No	Code No.	Subject	Semester	Credits
1.	BSC101	Physics (Mechanics & Mechanics of Solids)	I	5.5
2.	BSC103	Mathematics –I (Calculus, Multivariable Calculus and Linear Algebra)	I	4
3.	BSC 102	Chemistry-I	II	5.5
4.	BSC 104	Mathematics –II (Differential Equations)	II	4
5.	BSC 109	Biology for Engineers	III	3
6.	BSC225	Life Science	III	2
7.	BSC201	Mathematics-III (Transform & Discrete Mathematics)	III	2
			Total Credits:	**26**

ENGINEERING SCIENCE COURSES

Sl. No	Code No.	Subject	Semester	Credits
1.	ESC101	Basic Electrical Engineering	I	5
2.	ESC102	Programming for Problem Solving	II	5
3.	ESC104	Workshop Manufacturing Practices	II	3
4.	ESC105	Engineering Graphics & Design	I	3
5.	ESC202	Basic Electronics	III	2
6.	ESC203	Computer-aided Civil Engineering Drawing	III	2
7.	ESC205	Engineering Mechanics	III	4
8.	ESC212	Energy Science & Engineering	III	2
9.	ESC209	Mechanical Engineering	IV	3
			Total Credits:	**29**

PROFESSIONAL CORE COURSES/FUNDAMENTAL ENGINEERING PRINCIPLES & TOOLS

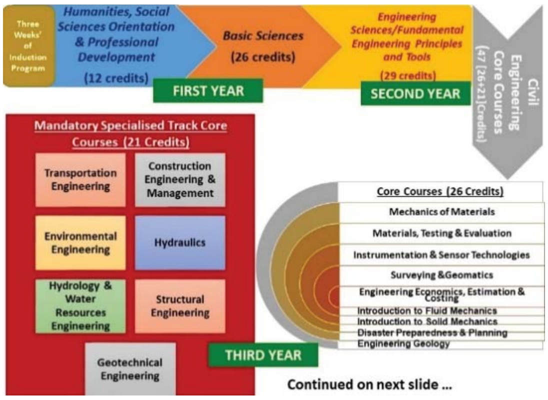
Sl. No	Code No.	Subject	Semester	Credits
1.	PCC-CE201	Instrumentation & Sensor Technologies for Civil Engineering Applications	IV	3
2.	PCC-CE202	Engineering Geology	IV	2
3.	PCC-CE203	Disaster Preparedness &Planning	IV	2
4.	PCC-CE204	Introduction to Fluid Mechanics	IV	3
5.	PCC-CE205	Introduction to Solid Mechanics	IV	2
6.	PCC-CE206	Surveying & Geomatics	IV	3
7.	PCC-CE207	Materials, Testing & Evaluation	IV	3
8.	PCC-CE301	Mechanics of Materials	V	3
9.	PCC-CE302	Hydraulic Engineering	V	3
10.	PCC-CE303	Structural Engineering	V	3
11.	PCC-CE304	Geotechnical Engineering	V	3
12.	PCC-CE305	Hydrology & Water Resources Engineering	V	3
13.	PCC-CE306	Environmental Engineering	V	3
14.	PCC-CE307	Transportation Engineering	V	3
15.	PCC-CE308	Construction Engineering & Management	VI	3
16.	PCC-CE309	Engineering Economics, Estimation & Costing	VI	5
			Total Credits:	**47**

PROFESSIONAL ELECTIVE COURSES

Sl. No	Code No.	Subject	Semester	Credits
1.	PEC-CEEL302	Elective-I	VI	3
2.	PEC-CEEL304	Elective-II	VI	3
3.	PEC-CEEL306	Elective-III	VI	3
4.	PEC-CEEL308	Elective-IV	VI	3
5.	PEC-CEEL401	Elective V	VII	3
6.	PEC-CEEL403	Elective-VI	VII	3
7.	PEC-CSEL402	Elective VII	VIII	3
8.	PEC-CSEL402	Elective VIII	VIII	2
			Total Credits:	**23**

OPEN ELECTIVE COURSES

Sl. No	Code No.	Subject	Semester	Credits
1.	OEEL302	Open Elective-I (Humanities)	VI	3
2.	OEEL401	Open Elective-II (Metro Systems & Engineering) – Suggested (See Annexure-I)	VII	3
3.	OEEL402	Open Elective-III	VIII	3
4.	OEEL403	Open Elective-IV	VIII	2
			Total Credits:	**11**


Three Weeks' of Induction Program
Humanities, Social Sciences Orientation & Professional Development (12 credits)
Basic Sciences (26 credits)
Engineering Sciences/Fundamental Engineering Principles and Tools (29 credits)
FIRST YEAR
SECOND YEAR
Civil Engineering Core Courses (47 [26+21]Credits)
Mandatory Specialised Track Core Courses (21 Credits)
Transportation Engineering
Construction Engineering & Management
Environmental Engineering
Hydraulics
Hydrology & Water Resources Engineering
Structural Engineering
Geotechnical Engineering
THIRD YEAR
Core Courses (26 Credits)
Mechanics of Materials
Materials, Testing & Evaluation
Instrumentation & Sensor Technologies
Surveying &Geomatics
Engineering Economics, Estimation & Costing
Introduction to Fluid Mechanics
Introduction to Solid Mechanics
Disaster Preparedness & Planning
Engineering Geology
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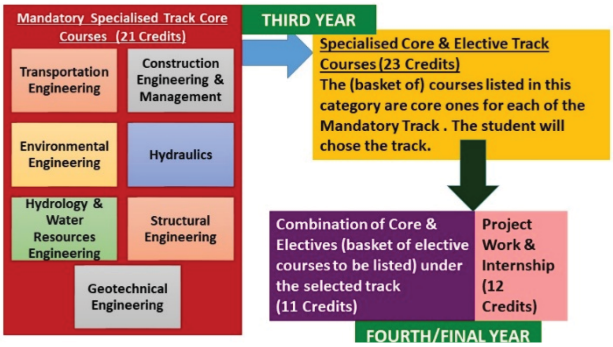
Mandatory Specialised Track Core Courses (21 Credits)
Transportation Engineering
Construction Engineering & Management
Environmental Engineering
Hydraulics
Hydrology & Water Resources Engineering
Structural Engineering
Geotechnical Engineering
THIRD YEAR
Specialised Core & Elective Track Courses (23 Credits)
The (basket of) courses listed in this category are core ones for each of the Mandatory Track . The student will chose the track.
Combination of Core & Electives (basket of elective courses to be listed) under the selected track (11 Credits)
Project Work & Internship (12 Credits)
FOURTH/FINAL YEAR

4 year Curriculum structure
Undergraduate Degree in Engineering & Technology

Branch / Course: Civil Engineering
Total credits (4 year course) 160

I. **Induction Program**(Please refer **Appendix-A** for guidelines. Details of Induction program also available in the curriculum of Mandatory courses.)

Induction program (mandatory)	**3 weeks duration** (Please refer Appendix-A for guidelines& also detailsavailable in the curriculum of Mandatory courses)
Induction program for students to be offered right at the start of the first year.	• Physical activity • Creative Arts • Universal Human Values • Literary • Proficiency Modules • Lectures by Eminent People • Visits to local Areas • Familiarization to Dept./Branch & Innovations

II. Semester-wise structure of curriculum

[L= Lecture, T = Tutorials, P = Practicals & C = Credits]

Semester I (First year]
Branch/Course Civil Engineering

Sl. No.	Category	Course Code	Course Title	Hours per week			Credits
				L	**T**	**P**	**C**
1	Basic Science course	BSC101	Physics (Mechanics & Mechanics of Solids)	3	1	3	5.5
2	Basic Science course	BSC103	Mathematics –I (Calculus, Multivariable Calculus and Linear Algebra)	3	1	0	4
3	Engineering Science Courses	ESC101	Basic Electrical Engineering	3	1	2	5
4	Engineering Science Courses	ESC105	Engineering Graphics & Design	1	0	4	3
						Total credits	**17.5**

Semester II (First year]
Branch/Course Civil Engineering

Sl. No.	Category	Code	Course Title	Hours per week			Credits
				L	**T**	**P**	
1	Basic Science courses	BSC 102	Chemistry-I	3	1	3	5.5
2	Basic Science courses	BSC 104	Mathematics –II (Differential Equations)	3	1	0	4
3	Engineering Science Courses	ESC102	Programming for Problem Solving	3	0	4	5
4	Engineering Science Courses	ESC104	Workshop Manufacturing Practices	1	0	4	3
5	Humanities and Social Sciences including Management courses	HSMC101	English	2	0	2	3
			Total credits				**20.5**

Semester III (Second year]
Branch/CourseCivil Engineering

Sl. No.	Category	Code	Course Title	Hours per week			Credits
				L	**T**	**P**	
1	Engineering Science Courses	ESC202	Basic Electronics	1	0	2	2
2	Basic Science courses	BSC 109	Biology for Engineers	2	0	2	3
3	Engineering Science Courses	ESC203	Computer-aided Civil Engineering Drawing	1	0	2	2
4	Engineering Science Courses	ESC205	Engineering Mechanics	3	1	0	4
5	Engineering Science Courses	ESC212	Energy Science & Engineering	1	1	0	2
6	Engineering Science Courses	BSC225	Life Science	1	0	2	2
7	Basic Science courses	BSC201	Mathematics-III (Transform & Discrete Mathematics)	2	0	0	2
8	Humanities and Social Sciences including Management courses	HSMC201	Humanities-I (Effective Technical Communication)	3	0	0	3
9	Humanities and Social Sciences including Management courses	HSMC251	Introduction to Civil Engineering	2	0	0	2
			Total credits				**22**

Semester IV (Second year]
Branch/Course Civil Engineering

Sl. No.	Category	Code	Course Title	Hours per week			Credits
				L	**T**	**P**	
1	Engineering Science Courses	ESC209	Mechanical Engineering	2	1	0	3
2	Professional Core courses	PCC-CE201	Instrumentation & Sensor Technologies for Civil Engineering Applications	1	1	2	3
3	Professional Core courses	PCC-CE202	Engineering Geology	1	0	2	2
4	Professional Core courses	PCC-CE203	Disaster Preparedness & Planning	1	1	0	2
5	Professional Core courses	PCC-CE204	Introduction to Fluid Mechanics	2	0	2	3
6	Professional Core courses	PCC-CE205	Introduction to Solid Mechanics	2	0	0	2
7	Professional Core courses	PCC-CE206	Surveying & Geomatics	1	1	2	3
8	Professional Core courses	PCC-CE207	Materials, Testing & Evaluation	1	1	2	3
9	Humanities and Social Sciences including Management courses	HSMC252	Civil Engineering - Societal & Global Impact	2	0	0	2
10	Mandatory Courses (non-credit)	MC-CE207 (same as HSMC202)	Management I (Organizational Behavior)	3	0	0	0
						Total credits	**23**

Semester V (Third year]
Branch/Course Civil Engineering

Sl. No.	Category	Code	Course Title	Hours per week			Total contact hours	Credits
				L	**T**	**P**		
1	Professional Core courses	PCC-CE301	Mechanics of Materials	3	0	0		3
2	Professional Core courses	PCC-CE302	Hydraulic Engineering	2	0	2		3
3	Professional Core courses	PCC-CE303	Structural Engineering	2	1	0		3
4	Professional Core courses	PCC-CE304	Geotechnical Engineering	2	0	2		3
5	Professional Core courses	PCC-CE305	Hydrology & Water Resources Engineering	2	2	0		3
6	Professional Core courses	PCC-CE306	Environmental Engineering	2	2	0		3
7	Professional Core courses	PCC-CE307	Transportation Engineering	2	0	2		3
8	Humanities and Social Sciences including Management courses	HSMC255	Professional Practice, Law & Ethics	2	0	0		2
9	Mandatory courses (non-credit)	MC-1	Constitution of India/ Essence of Indian Traditional Knowledge	-	-	-		0
							Total credits	**23**

Semester VI (Third year]
Branch/Course Civil Engineering

Sl. No.	Category	Code	Course Title	Hours per week			Credits
				L	**T**	**P**	
1	Professional Core courses	PCC-CE308	Construction Engineering & Management	2	1	0	3
2	Professional Core courses	PCC-CE309	Engineering Economics, Estimation & Costing	2	1	4	5
3	Professional Elective courses	PEC-CEEL302	Elective-I	3	0	0	3
4	Professional Elective courses	PEC-CEEL304	Elective-II	3	0	0	3
5	Open Elective courses	OEEL302	Open Elective-I (Humanities)	3	0	0	3
6	Professional Elective courses	PEC-CEEL306	Elective-III	3	0	0	3
7	Professional Elective courses	PEC-CEEL308	Elective-IV	3	0	0	3
			Total credits				**23**

Semester VII (Fourth year]
Branch/Course Civil Engineering

Sl. No.	Category	Code	Course Title	Hours per week			Credits
				L	**T**	**P**	
1	Professional Elective courses	PEC-CEEL401	Elective V	3	0	0	3
2	Professional Elective courses	PEC-CEEL403	Elective-VI	3	0	0	3
3	Open Elective courses	OEC401	Open Elective-II Suggested (Metro Systems & Engineering) See Annexure-I	3	0	0	3
4	Project	PROJ-CE401	Project-1 (Project work, seminar and internship in industry or at appropriate work place)	0	0	12	6
			Total credits				**15**

Semester VIII (Fourth year)
Branch/Course Civil Engineering

Sl. No.	Category	Code	Course Title	Hours per week			Total contact hours	Credits
				L	**T**	**P**		
1	Professional Elective Courses	PEC-CEEL402	Elective VII	3	0	0		3
2	Professional Elective Courses	PEC-CEEL402	Elective VIII	2	0	0		2
3	Open Elective courses	OEC- 403	Open Elective-III	3	0	0		3
4	Open Elective courses	OEC- 404	Open Elective-IV	2	0	0		2
5	Project	PROJ-CE402	Project-2 (Continued from VII Semester, Project work, seminar and internship in industry or at appropriate work place)	0	0	12		6
							Total credits	**16**

TOTAL CREDITS – 160

CHAPTER 2

PROFESSIONAL ELECTIVE COURSE TRACKS- CIVILENGINEERING [PEC-CE]

The following Seven Mandatory Professional Specialized Tracks offer electives in the respective Tracks:

Track	Professional Core Courses (PCC-CE)
I	Transportation Engineering
II	Construction Engineering & Management
III	Environmental Engineering
IV	Hydraulics
V	Hydrology & Water Resources Engineering
VI	Structural Engineering
VII	Geotechnical Engineering

besides the **Open Elective Courses.**

The students will have options of selecting the electives from the different tracks/threads depending on the specialization one wishes to acquire. **There should be at least two electives from the open elective course choices (OEC); the rest two can be taken from the other threads, if intended. This is provided in the following:**

Open Elective Courses[OEC]
Soft Skills and Interpersonal Communication
ICT for Development
Human Resource Development and Organizational Behavior
Cyber Law and Ethics
Introduction to Philosophical Thoughts
Comparative Study of Literature
Indian Music System
History of Science & Engineering
Introduction to Art and Aesthetics
Economic Policies in India
Metro Systems and Engineering

OEC 401	Metro Systems and Engineering	3L:0T:0P	3 credits

GENERAL: Overview of Metro Systems; Need for Metros; Routing studies; Basic Planning and Financials

CIVIL ENGINEERING-Overview and construction methods for: Elevated and underground Stations; Viaduct spans and bridges; Underground tunnels; Depots; Commercial and Service buildings. Initial Surveys & Investigations; Basics of Construction Planning & Management, Construction Quality & Safety Systems. Traffic integration, multimodal transfers and pedestrian facilities; Environmental and social safeguards; Track systems-permanent way. Facilities Management

ELECTRONICS AND COMMUNICATION ENGINEERING- Signaling systems; Automatic fare collection; Operation Control Centre (OCC and BCC); SCADA and other control systems; Platform Screen Doors.

MECHANICAL & TV + AC: Rolling stock, vehicle dynamics and structure; Tunnel Ventilation systems; Air conditioning for stations and buildings; Fire control systems; Lifts and Escalators

ELECTRICAL: OHE, Traction Power; Substations- TSS and ASS; Power SCADA; Standby and Back-up systems; Green buildings, Carbon credits and clear air mechanics.

The Professional Elective Courses (PEC-CE)are shown in different tracks. *The list is suggestive.The actual list of electives will depend on the availability of faculty and their research interests*. **However, there should be courses available in each track/thread.***On-line MOOC courses may contribute up to 20% of the credits, with in-house examination being conducted.****Please refer to Annexure-I of this document for key syllabus phrases for the course listed below.***

I Transportation Engineering

1. Pavement Materials
2. Pavement Design
3. Public Transportation Systems
4. Traffic Engineering and Management
5. Urban Transportation Planning.
6. Geometric Design of Highways
7. Airport Planning and Design
8. Railway Engineering
9. Intelligent Transportation Systems
10. Highway Construction and Management
11. Port and Harbour Engineering
12. High Speed Rail Engineering
13. Transportation Economics
14. Infrastructure Planning and Design

II Construction Engineering & Management

1. Construction Productivity
2. Building Construction Practice
3. Construction Project Planning&Systems
4. Construction Cost Analysis
5. Sustainable Construction Methods
6. Construction Engineering Materials.
7. Contracts Management
8. Construction Equipment& Automation
9. Repairs & Rehabilitation of Structures

III Environmental Engineering

1. Ecological Engineering
2. Environmental Systems
3. Transport of Water and Wastewater
4. Environmental Laws and Policy
5. Physico-Chemical Processes for Water and Wastewater Treatment

6. Biological Processes for Contaminant Removal
7. Rural Water Supply and Onsite Sanitation Systems
8. Water and Air Quality Modelling
9. Solid and Hazardous Waste Management
10. Air and Noise Pollution and Control
11. Environmental Impact Assessment and Life Cycle Analyses
12. Sustainable Engineering & Technology

IV Hydraulics

1. Design of hydraulic structures/Irrigation Engineering
2. Pipeline Engineering
3. Open Channel flow
4. River Engineering
5. Hydraulic modelling
6. Basics of computational hydraulics
7. Transients in closed conduits
8. Urban Hydrology and Hydraulics
9. Groundwater

V Hydrology & Water Resources Engineering

1. Water Quality Engineering
2. Surface Hydrology
3. Environmental Fluid Mechanics
4. Water Resources Field Methods

VI Structural Engineering

1. Reliability Analysis of Structures
2. Engineering Risk & Uncertainty
3. Decision and Risk Analysis
4. Engineering Materials for Sustainability
5. Concrete Materials
6. Wood Structures
7. Masonry Structures
8. Structural Analysis-I
9. Structural Analysis-II
10. Advanced Structural Analysis
11. Structural Analysis by Matrix Methods
12. Structural Mechanics
13. Reinforced Concrete
14. Concrete Technology
15. Design of Concrete Structures-I
16. Design of Concrete Structures-II
17. Prestressed Concrete
18. Design of Steel Structures
19. Metal Structure Behaviour- I
20. Metal Structure Behaviour- II
21. Bridge Engineering
22. Industrial Structures
23. Design of Structural Systems
24. Structural Dynamics
25. Earthquake Engineering
26. Civil Engineering Design-I
27. Civil Engineering Design-II
28. Geographic Information Systems and Science
29. Modelling and Analysis of Uncertainty
30. Systems Engineering & Economics

VII Geotechnical Engineering

1. Soil Mechanics-I
2. Soil Mechanics-II
3. Foundation Engineering
4. Geotechnical Design
5. Structural Geology
6. Offshore Engineering
7. Rock Mechanics
8. Environmental Geo-technology

CHAPTER 3

DETAILED 4-YEAR CURRICULUM CONTENTS

Undergraduate Degree in Engineering & Technology

Branch/Course: CIVIL ENGINEERING

[Please note: The lab component of the course should have one hour of tutorial followed or preceded by laboratory assignments wherever required.]

3.1 HUMANITIES & SOCIAL SCIENCES INCLUDING MANAGEMENT

HSMC101	**English**	**2L:0T:2P**	**3 credits**

Detailed contents

1. Vocabulary Building

1.1The concept of Word Formation
1.2Root words from foreign languages and their use in English
1.3Acquaintance with prefixes and suffixes from foreign languages in English to form derivatives.
1.4 Synonyms, antonyms, and standard abbreviations.

2. Basic Writing Skills

2.1 Sentence Structures
2.2 Use of phrases and clauses in sentences
2.3 Importance of proper punctuation
2.4 Creating coherence
2.5 Organizing principles of paragraphs in documents
2.6 Techniques for writing precisely

3. Identifying Common Errors in Writing

3.1 Subject-verb agreement
3.2 Noun-pronoun agreement
3.3 Misplaced modifiers
3.4 Articles
3.5 Prepositions
3.6 Redundancies
3.7 Clichés

4. Nature and Style of sensible Writing

4.1 Describing
4.2 Defining
4.3 Classifying
4.4 Providing examples or evidence
4.5 Writing introduction and conclusion

5. Writing Practices

5.1 Comprehension
5.2 Précis Writing
5.3 Essay Writing

6. Oral Communication

- (This unit involves interactive practice sessions in Language Lab)
- Listening Comprehension
- Pronunciation, Intonation, Stress and Rhythm
- Common Everyday Situations: Conversations and Dialogues
- Communication at Workplace
- Interviews
- Formal Presentations

Suggested Readings:

(i) Practical English Usage. Michael Swan. OUP. 1995.
(ii) Remedial English Grammar. F.T. Wood. Macmillan.2007
(iii)On Writing Well. William Zinsser. Harper Resource Book. 2001
(iv)Study Writing. Liz Hamp-Lyons and Ben Heasly. Cambridge University Press. 2006.
(v) Communication Skills. Sanjay Kumar and Pushp Lata. Oxford University Press. 2011.
(vi)Exercises in Spoken English. Parts. I-III. CIEFL, Hyderabad. Oxford University Press

Course Outcomes

The student will acquire basic proficiency in English including reading and listening comprehension, writing and speaking skills.

HSMC201	Effective Technical Communication	3L:0T:0P	3 credits

Module 1: Information Design and Development- Different kinds of technical documents, Information development life cycle, Organization structures, factors affecting information and document design, Strategies for organization, Information design and writing for print and for online media.

Module 2: Technical Writing, Grammar and Editing- Technical writing process, forms of discourse, Writing drafts and revising, Collaborative writing, creating indexes, technical writing style and language. Basics of grammar, study of advanced grammar, editing strategies to achieve appropriate technical style. Introduction to advanced technical communication, Usability, Hunan factors, Managing technical communication projects, time estimation, Single sourcing, Localization.

Module 3: Self Development and Assessment- Self assessment, Awareness, Perception and Attitudes, Values and belief, Personal goal setting, career planning, Self-esteem. Managing Time; Personal memory, Rapid reading, Taking notes; Complex problem solving; Creativity

Module 4: Communication and Technical Writing- Public speaking, Group discussion, Oral; presentation, Interviews, Graphic presentation, Presentation aids, Personality Development. Writing reports, project proposals, brochures, newsletters, technical articles, manuals, official notes, business letters, memos, progress reports, minutes of meetings, event report.

Module 5: Ethics- Business ethics, Etiquettes in social and office settings, Email etiquettes, Telephone Etiquettes, Engineering ethics, Managing time, Role and responsibility of engineer, Work culture in jobs, Personal memory, Rapid reading, Taking notes, Complex problem solving, Creativity.

Text/Reference Books:

1. David F. Beer and David McMurrey, Guide to writing as an Engineer, John Willey. New York, 2004
2. Diane Hacker, Pocket Style Manual, Bedford Publication, New York, 2003. (ISBN 0312406843)
3. Shiv Khera, You Can Win, Macmillan Books, New York, 2003.

4. Raman Sharma, Technical Communications, Oxford Publication, London, 2004.
5. Dale Jungk, Applied Writing for Technicians, McGraw Hill, New York, 2004. (ISBN: 07828357-4)
6. Sharma, R. and Mohan, K. Business Correspondence and Report Writing, TMH New Delhi 2002.
7. Xebec, Presentation Book, TMH New Delhi, 2000. (ISBN 0402213)

HSMC251	Introduction to Civil Engineering	2L:1T:0P	2 credits

When the students enter the college to pursue a degree in Civil Engineering and as well pursue a career in Civil Engineering after graduation, they need to understand the breadth and depth available in this field for possible engagement. When many alternative disciplines of engineering appear to offer apparently more glamourous avenues for advancement, the Civil Engineering student should realize the solid foundations available in this mother of all engineering disciplines. The students should understand the enormous possibilities available for creative and innovative works in this all pervasive field of engineering.

This course is designed to address the following:

- to give an understanding to the students of the vast breadth and numerous areas of engagement available in the overall field of Civil Engineering
- to motivate the student to pursue a career in one of the many areas of Civil Engineering with deep interest and keenness.
- To expose the students to the various avenues available for doing creative and innovative work in this field by showcasing the many monuments and inspiring projects of public utility.

Proposed Syllabus

What is Civil Engineering/ Infrastructure, History of Civil Engineering, Overview of ancient & modern civil engineering marvels, current national planning for civil engineering/ infrastructure projects, scope of work involved in various branches of Civil Engineering – Architecture & Town planning, Surveying & Geomatics, Structural Engineering, Construction Management, Construction materials, Hydrology and Water Resources Engineering, Hydraulic Engineering, Environmental Engineering &Sustainability, Pavement Engineering and construction, Traffic & Transportation Engineering and Management, Geotechnical Engineering, Ocean Engineering, Building Energy Efficiency, Basics of Contract Management, Professional Ethics, Avenues for entrepreneurial working, Creativity & Innovativeness in Civil Engineering,

Modules

1. **Basic Understanding**: What is Civil Engineering/ Infrastructure? Basics of Engineering and Civil Engineering; Broad disciplines of Civil Engineering; Importance of Civil Engineering, Possible scopes for a career
2. **History of Civil engineering**: Early constructions and developments over time; Ancient monuments & Modern marvels; Development of various materials of construction and methods of construction; Works of Eminent civil engineers

3. **Overview of National Planning for Construction and Infrastructure Development**; Position of construction industry vis-à-vis other industries, five year plan outlays for construction; current budgets for infrastructure works;
4. **Fundamentals of Architecture & Town Planning**: Aesthetics in Civil Engineering, Examples of great architecture, fundamentals of architectural design & town planning; Building Systems (HVAC, Acoustics, Lighting, etc.); LEED ratings; Development of Smart cities
5. **Fundamentals of Building Materials**: Stones, bricks, mortars, Plain, Reinforced & Prestressed Concrete, Construction Chemicals; Structural Steel, High Tensile Steel, Carbon Composites; Plastics in Construction; 3D printing; Recycling of Construction & Demolition wastes
6. **Basics of Construction Management & Contracts Management**: Temporary Structures in Construction; Construction Methods for various types of Structures; Major Construction equipment; Automation & Robotics in Construction; Modern Project management Systems; Advent of Lean Construction; Importance of Contracts Management
7. **Environmental Engineering & Sustainability**:Water treatment systems; Effluent treatment systems; Solid waste management; Sustainability in Construction;
8. **Geotechnical Engineering**: Basics of soil mechanics, rock mechanics and geology; various types of foundations; basics of rock mechanics & tunnelling
9. **Hydraulics, Hydrology &Water Resources Engineering**: Fundamentals of fluid flow, basics of water supply systems; Underground Structures; Underground Structures Multi-purpose reservoir projects
10. **Ocean Engineering**: Basics of Wave and Current Systems; Sediment transport systems; Ports & Harbours and other marine structures
11. **Power Plant Structures**: Chimneys, Natural & Induced Draught Colling towers, coal handling systems, ash handling systems; nuclear containment structures; hydro power projects
12. **Structural Engineering**: Types of buildings; tall structures; various types of bridges; Water retaining structures; Other structural systems; Experimental Stress Analysis; Wind tunnel studies;
13. **Surveying & Geomatics**: Traditional surveying techniques, Total Stations, Development of Digital Terrain Models; GPS, LIDAR;
14. **Traffic &Transportation Engineering**:Investments in transport infrastructure development in India for different modes of transport; Developments and challenges in integrated transport development in India: road, rail, port and harbour and airport sector; PPP in transport sector; Intelligent Transport Systems; Urban Public and Freight Transportation; Road Safety under heterogeneous traffic; Sustainable and resilient pavement materials, design, construction and management; Case studies and examples.
15. **Repairs & Rehabilitation of Structures:** Basics of corrosion phenomena and other structural distress mechanisms; some simple systems of rehabilitation of structures; Non-Destructive testing systems; Use of carbon fibre wrapping and carbon composites in repairs.
16. **Computational Methods, IT, IoT in Civil Engineering:** Typical software used in Civil Engineering- Finite Element Method, Computational Fluid Dynamics; Computational Geotechnical Methods; highway design (MX), Building Information Modelling; Highlighting typical available software systems (SAP, STAAD, ABAQUS, MATLAB,

ETAB, NASTRAN, NISA, MIKE 21, MODFLOW, REVIT, TEKLA, AUTOCAD,…GEOSTUDIO, EDUSHAKE, MSP, PRIMAVERA, ArcGIS, VisSIM, …)

17. **Industrial lectures**: Case studies of large civil engineering projects by industry professionals, covering comprehensive planning to commissioning;
18. **Basics of Professionalism**: Professional Ethics, Entrepreneurial possibilities in Civil Engineering, Possibilities for creative & innovative working, Technical writing Skills enhancement; Facilities Management; Quality & HSE Systems in Construction

ORGANISATION OF COURSE (2-1-0)

S. No.	Module [No of Lectures within brackets]	Tutorials
1	Basic Understanding (1)	Develop a matrix of various disciplines and possible roles for engineers in each
2	History of Civil engineering (1)	Identify 10 ancient monuments and ten modern marvels and list the uniqueness of each
3	Overview of National planning for Construction and Infrastructure Development (1)	Develop a Strategic Plan for Civil Engineering works for next ten years based on past investments and identify one typical on-going mega project in each area
4	Architecture & Town Planning (1)	Identify ten best civil engineering projects with high aesthetic appeal with one possible factor for each; List down the possible systems required for a typical Smart City
5	Building Materials (2)	Identify three top new materials and their potential in construction; Visit a Concrete Lab and make a report
6	Construction Management, Contracts management (2)	Identify 5 typical construction methods and list their advantages/ positive features
7	Environmental Engineering & Sustainability (2)	Environmental Engineering & Sustainability: Sustainability principles, Sustainable built environment, water treatment systems, good practices of wastewater management. examples of Solid and hazardous waste management, Air pollution and control
8	Geotechnical Engineering (2)	List top five tunnel projects in India and their features; collect and study geotechnical investigation report of any one Metro Rail (underground) project; Visit a construction site and make a site visit report
9	Hydraulics, Hydrology &Water Resources Engineering (1)	Identify three river interlinking projects and their features; visit a Hydraulics Lab and make a report
10	Ocean Engineering, Ports & Harbours (1)	Identify 5 typical ports in India and list the structures available in them; Visit a related/similar facility, if possible in nearby place and make a report
11	Power Plant Structures (1)	Collect the typical layout for a large thermal power plant and a large hydro power plant and identify all the structures and systems falling in them.
12	Structural Engineering (3)	Identify 5 unique features for typical buildings,

		bridges, tall structures and large span structures; Visit Structures Testing Lab/facility and make a report
13	Surveying & Geomatics (1)	Collect visual representations prepared by a Total Station and LIDAR and compare; Study typical Google street map and Google Earth Map and study how each can facilitate the other
14	Traffic & transportation (1)	Investments in transport infrastructure; Developments and challenges; Intelligent Transport Systems; Smart Cities, Urban Transport; Road Safety; Sustainable and resilient highway design principles; Plan a sustainable transport system for a city; Identify key features/components in the planning and design of a green field highway/airport/port/railway and the cost – economics.
15	Repairs & rehabilitation of Structures (1)	Collect the history of a major rehabilitation project and list the interesting features
16	Computational Methods, IT, IoT in Civil Engineering (2)	Visit an AutoCad lab and prepare a report; Identify ten interesting software systems used in Civil Engg and their key features
17	Industrial lectures (2)	For each case study list the interesting features
18	Basics of Professionalism (3)	List 5 cases of violation of professional ethics and list preventive measures; Identify 5 interesting projects and their positive features; Write 400 word reports on one ancient monument and a modern marvel of civil engineering
	TOTAL NO LECTURES =30	**15**

Text/Reference Books:

1. Patil, B.S.(1974), Legal Aspects of Building and Engineering Contract
2. The National Building Code, BIS, (2017)
3. RERA Act, (2017)
4. Meena Rao (2006), Fundamental concepts in Law of Contract, 3rd Edn. Professional Offset
5. Chandiramani, Neelima (2000), The Law of Contract: An Outline, 2nd Edn. Avinash Publications Mumbai
6. Avtarsingh (2002), Law of Contract, Eastern Book Co.
7. Dutt (1994), Indian Contract Act, Eastern Law House
8. Anson W.R.(1979), Law of Contract, Oxford University Press
9. Kwatra G.K.(2005), The Arbitration & Conciliation of Law in India with case law on UNCITRAL Model Law on Arbitration, Indian Council of Arbitration
10. Avtarsingh (2005), Law of Arbitration and Conciliation, Eastern Book Co.
11. Wadhera (2004), Intellectual Property Rights, Universal Law Publishing Co.
12. P. S. Narayan (2000), Intellectual Property Rights, Gogia Law Agency
13. T. Ramappa (2010), Intellectual Property Rights Law in India, Asia Law House
14. Bare text (2005), Right to Information Act
15. O.P. Malhotra, Law of Industrial Disputes, N.M. Tripathi Publishers
16. K.M. Desai(1946), The Industrial Employment (Standing Orders) Act

17. Rustamji R.F., Introduction to the Law of Industrial Disputes, Asia Publishing House
18. Vee, Charles & Skitmore, Martin (2003) Professional Ethics in the Construction Industry, Engineering Construction and Architectural management, Vol.10, Iss. 2, pp 117-127, MCB UP Ltd
19. American Society of Civil Engineers (2011) ASCE Code of Ethics – Principles Study and Application
20. Ethics in Engineering- M.W.Martin& R.Schinzinger, McGraw-Hill
21. Engineering Ethics, National Institute for Engineering Ethics, USA
22. www.ieindia.org
23. Engineering ethics: concepts and cases – C. E. Harris, M.S. Pritchard, M.J.Rabins
24. Resisting Bureaucratic Corruption: Alacrity Housing Chennai (Teaching Case Study) -S. Ramakrishna Velamuri -CEIBS
25. CONSTRUCTION CONTRACTS, http://www.jnormanstark.com/contract.htm
26. Internet and Business Handbook, Chap 4, CONTRACTS LAW, http://www.laderapress.com/laderapress/contractslaw1.html
27. Contract &Agreements , http://www.tco.ac.ir/law/English/agreements/General/Contract%20Law/C.htm
28. Contracts, http://206.127.69.152/jgretch/crj/211/ch7.ppt
29. Business & Personal Law. Chapter 7. “How Contracts Arise”, http://yucaipahigh.com/schristensen/lawweb/lawch7.ppt
30. Types of Contracts, http://cmsu2.cmsu.edu/public/classes/rahm/meiners.con.ppt
31. IV. TYPES OF CONTRACTS AND IMPORTANT PROVISIONS, http://www.worldbank.org/html/opr/consult/guidetxt/types.html
32. Contract Types/Pricing Arrangements Guideline- 1.4.G (11/04/02), http://www.sandia.gov/policy/14g.pdf

Goals & Outcomes:

- Introduction to what constitutes Civil Engineering
- Identifying the various areas available to pursue and specialize within the overall field of Civil Engineering
- Highlighting the depth of engagement possible within each of these areas
- Exploration of the various possibilities of a career in this field
- Understanding the vast interfaces this field has with the society at large
- Providing inspiration for doing creative and innovative work
- Showcasing the many monuments, heritage structures, nationally important infrastructure, and impressive projects to serve as sources of inspiration
- Highlighting possibilities for taking up entrepreneurial activities in this field
- Providing a foundation for the student to launch off upon an inspired academic pursuit into this branch of engineering

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HSMC252	**Civil Engineering – Societal & Global Impact**	**2L:0T:0P**	**2 credits**

The course is designed to provide a better understanding of the impact which Civil Engineering has on the Society at large and on the global arena. Civil Engineering projects have an impact on the Infrastructure, Energy consumption and generation, Sustainability of the Environment, Aesthetics of the environment, Employment creation, Contribution to the GDP, and on a more perceptible level, the Quality of Life. It is important for the civil engineers to realise the impact which this field has and take appropriate precautions to ensure that the impact is not adverse but beneficial.

The course covers:

- Awareness of the importance of Civil Engineering and the impact it has on the Society and at global levels
- Awareness of the impact of Civil Engineering for the various specific fields of human endeavour
- Need to think innovatively to ensure Sustainability

Module 1: Introduction to Course and Overview; Understanding the past to look into the future: Pre-industrial revolution days, Agricultural revolution, first and second industrial revolutions, IT revolution; Recent major Civil Engineering breakthroughs and innovations; Present day world and future projections, Ecosystems in Society and in Nature; the steady erosion in Sustainability; Global warming, its impact and possible causes; Evaluating future requirements for various resources; GIS and applications for monitoring systems; Human Development Index and Ecological Footprint of India Vs other countries and analysis;

Module 2: Understanding the importance of Civil Engineering in shaping and impacting the world; The ancient and modern Marvels and Wonders in the field of Civil Engineering; Future Vision for Civil Engineering

Module 3: Infrastructure - Habitats, Megacities, Smart Cities, futuristic visions; Transportation (Roads, Railways & Metros, Airports, Seaports, River ways, Sea canals, Tunnels (below ground, under water); Futuristic systems (ex, Hyper Loop)); Energy generation (Hydro, Solar (Photovoltaic, Solar Chimney), Wind, Wave, Tidal, Geothermal, Thermal energy); Water provisioning; Telecommunication needs (towers, above-ground and underground cabling); Awareness of various Codes & Standards governing Infrastructure development; Innovations and methodologies for ensuring Sustainability;

Module 4: Environment- Traditional & futuristic methods; Solid waste management, Water purification, Wastewater treatment & Recycling, Hazardous waste treatment; Flood control (Dams, Canals, River interlinking), Multi-purpose water projects, Atmospheric pollution; Global warming phenomena and Pollution Mitigation measures, Stationarity and non-stationarity; Environmental Metrics & Monitoring; Other Sustainability measures; Innovations and methodologies for ensuring Sustainability.

Module 5: Built environment – Facilities management, Climate control; Energy efficient built environments and LEED ratings, Recycling, Temperature/ Sound control in built environment, Security systems; Intelligent/ Smart Buildings; Aesthetics of built environment, Role of Urban Arts Commissions; Conservation, Repairs & Rehabilitation of Structures & Heritage structures; Innovations and methodologies for ensuring Sustainability

Module 6: Civil Engineering Projects – Environmental Impact Analysis procedures; Waste (materials, manpower, equipment) avoidance/ Efficiency increase; Advanced construction techniques for better sustainability; Techniques for reduction of Green House Gas emissions in various aspects of Civil Engineering Projects; New Project Management paradigms & Systems (Ex. Lean Construction), contribution of Civil Engineering to GDP, Contribution to employment(projects, facilities management), Quality of products, Health & Safety aspects for stakeholders; Innovations and methodologies for ensuring Sustainability during Project development;

ORGANISATION OF COURSE (2-0-0)

S. No.	**Module**	**No of Lectures**	**Details**
1	Introduction	3	
2	Understanding the Importance of Civil Engineering	3	
3	Infrastructure	8	
4	Environment	7	
5	Built Environment	5	
6	Civil Engineering Projects	4	
	TOTAL	**30**	

Text/Reference Books:

1. *Žiga* Turk (2014), Global Challenges and the Role of Civil Engineering, Chapter 3 in: Fischinger M. (eds) Performance-Based Seismic Engineering: Vision for an Earthquake Resilient Society. Geotechnical, Geological and Earthquake Engineering, Vol. 32. Springer, Dordrecht
2. Brito, Ciampi, Vasconcelos, Amarol, Barros (2013) Engineering impacting Social, Economical and Working Environment, 120th ASEE Annual Conference and Exposition
3. NAE Grand Challenges for Engineering (2006), Engineering for the Developing World, The Bridge, Vol 34, No.2, Summer 2004.
4. Allen M. (2008) Cleansing the city. Ohio University Press. Athens Ohio.
5. Ashley R., Stovin V., Moore S., Hurley L., Lewis L., Saul A. (2010). London Tideway Tunnels Programme – Thames Tunnel Project Needs Report – Potential source control and SUDS applications: Land use and retrofit options
6. http://www.thamestunnelconsultation.co.uk/consultation-documents.aspx
7. Ashley R M., Nowell R., Gersonius B., Walker L. (2011). Surface Water Management and Urban Green Infrastructure. Review of Current Knowledge. Foundation for Water Research FR/R0014
8. Barry M. (2003) Corporate social responsibility – unworkable paradox or sustainable paradigm? Proc ICE Engineering Sustainability 156. Sept Issue ES3 paper 13550. p 129-130
9. Blackmore J M., Plant R A J. (2008). Risk and resilience to enhance sustainability with application to urban water systems. J. Water Resources Planning and Management. ASCE. Vol. 134, No. 3, May.
10. Bogle D. (2010) UK's engineering Council guidance on sustainability. Proc ICE Engineering Sustainability 163. June Issue ES2 p61-63
11. Brown R R., Ashley R M., Farrelly M. (2011). Political and Professional Agency Entrapment: An Agenda for Urban Water Research**.** Water Resources Management. Vol. 23, No.4. European Water Resources Association (EWRA) ISSN 0920-4741.

12. Brugnach M., Dewulf A., Pahl-Wostl C., Taillieu T. (2008) Toward a relational concept of uncertainty: about knowing too little, knowing too differently and accepting not to know. Ecology and Society 13 (2): 30
13. Butler D., Davies J. (2011). Urban Drainage. Spon. 3rd Ed.
14. Cavill S., Sohail M. (2003) Accountability in the provision of urban services. Proc. ICE. Municipal Engineer 156. Issue ME4 paper 13445, p235-244.
15. Centre for Water Sensitive Cities (2012) Blueprint for a water sensitive city. Monash University.
16. Charles J A. (2009) Robert Rawlinson and the UK public health revolution. Proc ICE Eng History and Heritage. 162 Nov. Issue EH4. p 199-206

What the student will learn? To develop an understanding of:

- The impact which Civil Engineering projects have on the Society at large and on the global arena and using resources efficiently and effectively.
- The extent of Infrastructure, its requirements for energy and how they are met: past, present and future
- The Sustainability of the Environment, including its Aesthetics,
- The potentials of Civil Engineering for Employment creation and its Contribution to the GDP
- The Built Environment and factors impacting the Quality of Life
- The precautions to be taken to ensure that the above-mentioned impacts are not adverse but beneficial.
- Applying professional and responsible judgement and take a leadership role;

HSMC255	**Professional Practice, Law & Ethics**	**2L:0T:0P**	**2 credits**

Basic elements of civil engineering professional practice are introduced in this course. Roles of all participants in the process-owners, developers, designers, consultants, architects, contractors, and suppliers - are described. Basic concepts in professional practice, business management, public policy, leadership, and professional licensure are introduced. The course covers professional relations, civic responsibilities, and ethical obligations for engineering practice. The course also describes contracts management, and various legal aspects related to engineering. Further, the course familiarizes students with elementary knowledge of laws that would be of utility in their profession, including several new areas of law such as IPR, ADR.

The course is designed to address the following:

- To make the students understand the types of roles they are expected to play in the society as practitioners of the civil engineering profession
- To develop some ideas of the legal and practical aspects of their profession

Proposed Syllabus

Professional practice covering the respective roles of the various stakeholders in the profession of civil engineering and the factors governing the same; Professional ethics relating to civil engineering; Various aspects of contracts relating to construction and management of contracts; types of contractual and other disputes in the profession and methods of dispute resolution; legal aspects relating to employment and service conditions of labour; intellectual property rights and their legal framework

Modules:

Module 1 A- Professional Practice – Respective roles of various stakeholders: Government (constituting regulatory bodies and standardization organizations, prescribing norms to ensure safety of the citizens); Standardization Bodies (ex. BIS, IRC)(formulating standards of practice); professional bodies (ex. Institution of Engineers(India), Indian Roads Congress, IIA/ COA, ECI, Local Bodies/ Planning Authorities) (certifying professionals and offering platforms for interaction); Clients/ owners (role governed by contracts); Developers (role governed by regulations such as RERA); Consultants (role governed by bodies such as CEAI); Contractors (role governed by contracts and regulatory Acts and Standards); Manufacturers/ Vendors/ Service agencies (role governed by contracts and regulatory Acts and Standards)

Module 1 B- Professional Ethics – Definition of Ethics, Professional Ethics, Business Ethics, Corporate Ethics, Engineering Ethics, Personal Ethics; Code of Ethics as defined in the website of Institution of Engineers (India); Profession, Professionalism, Professional Responsibility, Professional Ethics; Conflict of Interest, Gift Vs Bribery, Environmental breaches, Negligence, Deficiencies in state-of-the-art; Vigil Mechanism, Whistleblowing, protected disclosures.

Module 2:*General Principles of Contracts Management: Indian Contract Act, 1972 and amendments* covering General principles of contracting; Contract Formation & Law; Privacy of contract; Various types of contract and their features; Valid & Voidable Contracts; Prime and sub-contracts; Joint Ventures & Consortium; Complex contract terminology; Tenders, Request For Proposals, Bids & Proposals; Bid Evaluation; Contract Conditions & Specifications; Critical /"Red Flag" conditions; Contract award & Notice To Proceed; Variations & Changes in Contracts; Differing site conditions; Cost escalation; Delays, Suspensions & Terminations; Time extensions & Force Majeure; Delay Analysis; Liquidated damages & Penalties; Insurance & Taxation; Performance and Excusable Non-performance; Contract documentation; Contract Notices; Wrong practices in contracting (Bid shopping, Bid fixing, Cartels); Reverse auction; Case Studies; Build-Own-Operate & variations; Public-Private Partnerships; International Commercial Terms;

Module 3 :*Arbitration, Conciliation and ADR (Alternative Dispute Resolution) system:* Arbitration – meaning, scope and types – distinction between laws of 1940 and 1996; UNCITRAL model law – Arbitration and expert determination; Extent of judicial intervention; International commercial arbitration; Arbitration agreements – essential and kinds, validity, reference and interim measures by court; Arbitration tribunal – appointment, challenge, jurisdiction of arbitral tribunal, powers, grounds of challenge, procedure and court assistance; Award including Form and content, Grounds for setting aside an award, Enforcement, Appeal and Revision; Enforcement of foreign awards – New York and Geneva Convention Awards; Distinction between conciliation, negotiation, mediation and arbitration, confidentiality, resort to judicial proceedings, costs; Dispute Resolution Boards; Lok Adalats

Module 4 :*Engagement of Labour and Labour & other construction-related Laws:* Role of Labour in Civil Engineering; Methods of engaging labour- on rolls, labour sub-contract, piece rate work; Industrial Disputes Act, 1947; Collective bargaining; Industrial Employment (Standing Orders) Act, 1946; Workmen's Compensation Act, 1923; Building & Other Construction Workers (regulation of employment and conditions of service) Act (1996) and Rules (1998); RERA Act 2017, NBC 2017

Module 5 : *Law relating to Intellectual property:* Introduction – meaning of intellectual property, main forms of IP, Copyright, Trademarks, Patents and Designs, Secrets; Law relating to Copyright in India including Historical evolution of Copy Rights Act, 1957, Meaning of copyright – computer programs, Ownership of copyrights and assignment, Criteria of infringement, Piracy in Internet – Remedies and procedures in India; Law relating to Patents under Patents Act, 1970 including Concept and historical perspective of patents law in India, Patentable inventions with special reference to biotechnology products, Patent protection for computer programs, Process of obtaining patent – application, examination, opposition and sealing of patents, Patent cooperation treaty and grounds for opposition, Rights and obligations of patentee, Duration of patents – law and policy considerations, Infringement and related remedies;

ORGANISATION OF COURSE (2-0-0)

S. No	Module	No of Lectures	Details
1A	Professional Practice	2	
1B	Professional Ethics	2	
2	Contracts Management	18	
3	Dispute Resolution Mechanisms	5	
4	Labour; Labour & other Laws	2	
5	Intellectual Property Management	1	
	TOTAL	**30**	

Text/Reference Books:

1. B.S. Patil, Legal Aspects of Building and Engineering Contracts, 1974.
2. The National Building Code, BIS, 2017
3. RERA Act, 2017
4. Meena Rao (2006), Fundamental concepts in Law of Contract, 3rd Edn. Professional Offset
5. Neelima Chandiramani (2000), The Law of Contract: An Outline, 2nd Edn. Avinash Publications Mumbai
6. Avtarsingh (2002), Law of Contract, Eastern Book Co.
7. Dutt (1994), Indian Contract Act, Eastern Law House
8. Anson W.R. (1979), Law of Contract, Oxford University Press
9. Kwatra G.K. (2005), The Arbitration & Conciliation of Law in India with case law on UNCITRAL Model Law on Arbitration, Indian Council of Arbitration
10. Wadhera (2004), Intellectual Property Rights, Universal Law Publishing Co.
11. T. Ramappa (2010), Intellectual Property Rights Law in India, Asia Law House
12. Bare text (2005), Right to Information Act
13. O.P. Malhotra, Law of Industrial Disputes, N.M. Tripathi Publishers
14. K.M. Desai(1946), The Industrial Employment (Standing Orders) Act
15. Rustamji R.F., Introduction to the Law of Industrial Disputes, Asia Publishing House

16. Vee, Charles & Skitmore, Martin (2003) Professional Ethics in the Construction Industry, Engineering Construction and Architectural management, Vol.10, Iss2,pp 117-127, MCB UP Ltd
17. American Society of Civil Engineers (2011) ASCE Code of Ethics – Principles Study and Application
18. Ethics in Engineering- M.W.Martin& R.Schinzinger, McGraw-Hill
19. Engineering Ethics, National Institute for Engineering Ethics, USA
20. www.ieindia.org
21. Engineering ethics: concepts and cases – C. E. Harris, M.S. Pritchard, M.J.Rabins
22. CONSTRUCTION CONTRACTS, http://www.jnormanstark.com/contract.htm
23. Internet and Business Handbook, Chap 4, CONTRACTS LAW, http://www.laderapress.com/laderapress/contractslaw1.html
24. Contract&Agreements http://www.tco.ac.ir/law/English/agreements/General/Contract%20Law/C.htm
25. Contracts, http://206.127.69.152/jgretch/crj/211/ch7.ppt
26. Business & Personal Law. Chapter 7. "How Contracts Arise", http://yucaipahigh.com/schristensen/lawweb/lawch7.ppt
27. Types of Contracts, http://cmsu2.cmsu.edu/public/classes/rahm/meiners.con.ppt
28. IV. TYPES OF CONTRACTS AND IMPORTANT PROVISIONS, http://www.worldbank.org/html/opr/consult/guidetxt/types.html
29. Contract Types/Pricing Arrangements Guideline- 1.4.G (11/04/02), http://www.sandia.gov/policy/14g.pdf

Goals & Outcomes:

- To familiarise the students to what constitutes professional practice, introduction of various stakeholders and their respective roles; understanding the fundamental ethics governing the profession
- To give a good insight into contracts and contracts management in civil engineering, dispute resolution mechanisms; laws governing engagement of labour
- To give an understanding of Intellectual Property Rights, Patents.
- To make the students understand the types of roles they are expected to play in the society as practitioners of the civil engineering profession
- To develop good ideas of the legal and practical aspects of their profession

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3.2 BASIC SCIENCE COURSES

BSC 101	**Physics**	**3L:1T:3P**	**5.5 credits**

Physics 1: Mechanics

Prerequisites:(i) High-school education

Module 1: Vector mechanics of particles **(20)**
Transformation of scalars and vectors under Rotation transformation; Forces in Nature; Newton's laws and its completeness in describing particle motion; Form invariance of Newton's Second Law; Solving Newton's equations of motion in polar coordinates; Problems including constraints and friction; Extension to cylindrical and spherical coordinates; Potential energy function; F = - Grad V; Conservative and non-conservative forces; Central forces; Conservation of Angular Momentum; Energy equation and energy diagrams; Elliptical, parabolic and hyperbolic orbits; Application: Satellite manoeuvres; Non-inertial frames of reference; Rotating coordinate system: Five-term acceleration formula — Centripetal and Coriolis accelerations; Applications: Weather systems, Foucault pendulum; Harmonic oscillator; Damped harmonic motion; Forced oscillations and resonance;

Module 2: Planar rigid body mechanics **(10)**
De*finition and motion of a rigid body in the plane; Rotation in the plane; Kinematics in a* coordinate system rotating and translating in the plane; Angular momentum about a point of a rigid body in planar motion; Euler's laws of motion, their independence from Newton's laws, and their necessity in describing rigid body motion; Examples;

Introduction to three-dimensional rigid body motion — only need to highlight the distinction from two- dimensional motion in terms of (a) Angular velocity vector, and its rate of change and (b) Moment of inertia tensor; Three-dimensional motion of a rigid body wherein all points move in a coplanar manner:
e.g. Rod executing conical motion with center of mass *fixed* — only need to show that this motion looks two-dimensional but is three-dimensional, and two-dimensional formulation fails.

Reference books:
- (i) Engineering Mechanics, 2nd ed. — MK Harbola
- (ii) Introduction to Mechanics — MK Verma
- (iii) An Introduction to Mechanics — D Kleppner & R Kolenkow
- (iv) Principles of Mechanics — JL Synge & BA Griffi*ths*
- (v) Mechanics — JP Den Hartog
- (vi) Engineering Mechanics - Dynamics, 7th ed. - JL Meriam
- (vii) Mechanical Vibrations — JP Den Hartog
- (viii) Theory of Vibrations with Applications — WT Thomson

Mechanics of Solids

Prerequisites: (i) Physics 1, both modules
(ii) Mathematics course with ordinary di*fferential equations*

Module 1: Statics **(10)**
Free body diagrams with examples on modelling of typical supports and joints; Condition for equilibrium in three- and two- dimensions; Friction: limiting and non-limiting cases; Force-displacement relationship; Geometric compatibility for small deformations; Illustrations through simple problems on axially loaded members like trusses.

Module 2: Mechanics of solids **(30)**
Concept of stress at a point; Planet stress: transformation of stresses at a point, principal stresses and Mohr's circle; Displacement *field; Concept of strain at a point; Plane strain:* transformation of strain at a point, principal strains and Mohr's circle; Strain Rosette; Discussion of experimental results on one- dimensional material behaviour; Concepts of elasticity, plasticity, strain hardening, failure (fracture / yielding); Idealization of one-dimensional stress-strain curve; Generalized Hooke's law with and without thermal strains for isotropic materials; Complete equations of elasticity; Force analysis — axial force, shear force, bending moment and twisting moment diagrams of slender members (without using singularity functions); Torsion of circular shafts and thin-walled tubes (plastic analysis and rectangular shafts not to be discussed); Moment curvature relationship for pure bending of beams with symmetric cross-section; Bending stress; Shear stress; Cases of combined stresses; Concept of strain energy; Yield criteria; De*flection due to bending; Integration of* the moment-curvature relationship for simple boundary conditions; Method of superposition (without using singularity functions); Strain energy and complementary strain energy for simple structural elements (i.e. those under axial load, shear force, bending moment and torsion); Castigliano's theorems for de*flection analysis and indeterminate problems.*

Reference books:
(i) An Introduction to the Mechanics of Solids, 2nd ed. with SI Units — SH Crandall, NC Dahl & TJ Lardner
(ii) Engineering Mechanics: Statics, 7th ed. — JL Meriam
(iii) Engineering Mechanics of Solids — EP Popov

Model Chemistry/Biology Courses

In view of the inclusion of 6 credits for chemistry and 3 credits for biology for the B.E/B. Tech/equivalent students, the chemistry and biology courses are organized as follows:

Compulsory courses
1) Chemistry-I (Concepts in chemistry for engineering) – (4 credits)
2) Chemistry Laboratory – (2 credits)
3) Biology(3 Credits)

Elective courses
1) Chemistry-II (Chemical Applications) – 4 credits/3 credits
2) Polymer Chemistry (3 credits)
3) Experiments in Polymer Chemistry (2 Credits)

Chemistry-I (Concepts in chemistry for engineering) will have a strong emphasis on the concepts that will aid in quantification of several concepts in chemistry that have been introduced at the 10+2 levels in schools. Technology is being increasingly based on the electronic, atomic and molecular level modifications. Quantum theory is more than 100 years old and to understand phenomena at nanometer levels, one has to base the description of all chemical processes at molecular levels. The course will emphasize on learning microscopic chemistry in terms of atomic and molecular orbitals and intermolecular forces. Principles of different spectroscopic techniques will be introduced and some applications will be considered. Bulk properties and processes will be analysed using thermodynamic considerations. There will also be outlines of periodic properties, stereochemistry, chemical reactions and synthesis. The chemistry laboratory course will consist of experiments illustrating the principles of chemistry that have been learnt so far, as well as others relevant to the study of science and engineering.

The course Chemistry – II (Chemical Applications) which is an elective course, will explore applications of chemistry that includes polymers, surfactants, nanomaterials, environmental and green chemistry, biomolecules and analytical techniques.

Courses in Polymer Chemistry and Experiments in Polymer Chemistry are electives.

The course Biology is a compulsory course that conveys that Biology is as important a scientific discipline as Mathematics, Physics and Chemistry. It also conveys that 1) "Genetics is to biology what Newton's laws are to Physical Sciences", 2) all forms of life have the same building blocks and yet the manifestations are as diverse as one can imagine, 3) without catalysis life would not have existed on earth, 4) molecular basis of coding and decoding (genetic information) is universal and that 5) fundamental principles of chemical and physical energy transactions are the same in physical/chemical and biological world.

BSC102	**Chemistry-I**	**3L:1T:3P**	**5.5 credits**

Detailed contents

(i) Atomic and molecular structure (12 lectures)

Schrodinger equation. Particle in a box solutions and their applications for conjugated molecules and nanoparticles. Forms of the hydrogen atom wave functions and the plots of these functions to explore their spatial variations. Molecular orbitals of diatomic molecules and plots of the multicentre orbitals. Equations for atomic and molecular orbitals. Energy level diagrams of diatomics. Pi-molecular orbitals of butadiene and benzene and aromaticity. Crystal field theory and the energy level diagrams for transition metal ions and their magnetic properties. Band structure of solids and the role of doping on band structures.

(ii) Spectroscopic techniques and applications (8 lectures)

Principles of spectroscopy and selection rules. Electronic spectroscopy. Fluorescence and its applications in medicine. Vibrational and rotational spectroscopy of diatomic molecules. Applications. Nuclear magnetic resonance and magnetic resonance imaging, surface characterisation techniques. Diffraction and scattering.

(iii) Intermolecular forces and potential energy surfaces (4 lectures)

Ionic, dipolar and van Der Waals interactions. Equations of state of real gases and critical phenomena. Potential energy surfaces of H_3, H_2F and HCN and trajectories on these surfaces.

(iv) Use of free energy in chemical equilibria (6 lectures)

Thermodynamic functions: energy, entropy and free energy. Estimations of entropy and free energies. Free energy and emf. Cell potentials, the Nernst equation and applications. Acid base, oxidation reduction and solubility equilibria. Water chemistry. Corrosion. Use of free energy considerations in metallurgy through Ellingham diagrams.

(v) Periodic properties (4 Lectures)

Effective nuclear charge, penetration of orbitals, variations of s, p, d and f orbital energies of atoms in the periodic table, electronic configurations, atomic and ionic sizes, ionization energies, electron affinity and electronegativity, polarizability, oxidation states, coordination numbers and geometries, hard soft acids and bases, molecular geometries

(vi) Stereochemistry (4 lectures)

Representations of 3 dimensional structures, structural isomers and stereoisomers, configurations and symmetry and chirality, enantiomers, diastereomers, optical activity, absolute configurations and conformational analysis. Isomerism in transitional metal compounds

(vii) Organic reactions and synthesis of a drug molecule (4 lectures)

Introduction to reactions involving substitution, addition, elimination, oxidation, reduction, cyclization and ring openings. Synthesis of a commonly used drug molecule.

Suggested Text Books

(i) University chemistry, by B. H. Mahan
(ii) Chemistry: Principles and Applications, by M. J. Sienko and R. A. Plane
(iii) Fundamentals of Molecular Spectroscopy, by C. N. Banwell
(iv) Engineering Chemistry (NPTEL Web-book), by B. L. Tembe, Kamaluddin and M. S. Krishnan
(v) Physical Chemistry, by P. W. Atkins
(vi) Organic Chemistry: Structure and Function by K. P. C. Volhardt and N. E. Schore, 5th Edition http://bcs.whfreeman.com/vollhardtschore5e/default.asp

Course Outcomes

The concepts developed in this course will aid in quantification of several concepts in chemistry that have been introduced at the 10+2 levels in schools. Technology is being increasingly based on the electronic, atomic and molecular level modifications.

Quantum theory is more than 100 years old and to understand phenomena at nanometer levels, one has to base the description of all chemical processes at molecular levels. The course will enable the student to:

- Analyse microscopic chemistry in terms of atomic and molecular orbitals and intermolecular forces.
- Rationalise bulk properties and processes using thermodynamic considerations.
- Distinguish the ranges of the electromagnetic spectrum used for exciting different molecular energy levels in various spectroscopic techniques
- Rationalise periodic properties such as ionization potential, electronegativity, oxidation states and electronegativity.
- List major chemical reactions that are used in the synthesis of molecules.

(ii)Chemistry Laboratory

Choice of 10-12 experiments from the following:

- Determination of surface tension and viscosity
- Thin layer chromatography
- Ion exchange column for removal of hardness of water
- Determination of chloride content of water
- Colligative properties using freezing point depression
- Determination of the rate constant of a reaction
- Determination of cell constant and conductance of solutions
- Potentiometry - determination of redox potentials and emfs
- Synthesis of a polymer/drug
- Saponification/acid value of an oil
- Chemical analysis of a salt
- Lattice structures and packing of spheres
- Models of potential energy surfaces
- Chemical oscillations- Iodine clock reaction
- Determination of the partition coefficient of a substance between two immiscible liquids
- Adsorption of acetic acid by charcoal
- Use of the capillary viscosimeters to the demonstrate of the isoelectric point as the pH of minimum viscosity for gelatin sols and/or coagulation of the white part of egg .

Laboratory Outcomes

- The chemistry laboratory course will consist of experiments illustrating the principles of chemistry relevant to the study of science and engineering. The students will learn to:
- Estimate rate constants of reactions from concentration of reactants/products as a function of time
- Measure molecular/system properties such as surface tension, viscosity, conductance of solutions, redox potentials, chloride content of water, etc
- Synthesize a small drug molecule and analyse a salt sample

BSC109	Biology (Biology for Engineers)	2L:1T:0P	3 credits

[3 credit course; 2 (one hour) lectures and one (one hour) tutorial per week.
Only lecture hours are shown]

Module 1. *(2 hours)- Introduction*
Purpose: To convey that Biology is as important a scientific discipline as Mathematics, Physics and Chemistry
Bring out the fundamental differences between science and engineering by drawing a comparison between eye and camera, Bird flying and aircraft. Mention the most exciting aspect of biology as an independent scientific discipline. Why we need to study biology? Discuss how biological observations of 18th Century that lead to major discoveries. Examples from Brownian motion and the origin of thermodynamics by referring to the original observation of Robert Brown and Julius Mayor. These examples will highlight the fundamental importance of observations in any scientific inquiry.

Module 2. *(3 hours)- Classification*
Purpose: To convey that classification *per se* is not what biology is all about. The underlying criterion, such as morphological, biochemical or ecological be highlighted.
Hierarchy of life forms at phenomenological level. A common thread weaves this hierarchy Classification. Discuss classification based on (a) cellularity- Unicellular or multicellular (b) ultrastructure- prokaryotes or eucaryotes. (c) energy and Carbon utilization -Autotrophs, heterotrophs, lithotropes (d) Ammonia excretion – aminotelic, uricoteliec, ureotelic (e) Habitata- acquatic or terrestrial (e) Molecular taxonomy- three major kingdoms of life. A given organism can come under different category based on classification. Model organisms for the study of biology come from different groups. E.coli, S.cerevisiae, D. Melanogaster, C. elegance, A. Thaliana, M. musculus

Module 3. *(4 hours)-Genetics*
Purpose: To convey that “Genetics is to biology what Newton’s laws are to Physical Sciences”
Mendel’s laws, Concept of segregation and independent assortment. Concept of allele. Gene mapping, Gene interaction, Epistasis. Meiosis and Mitosis be taught as a part of genetics. Emphasis to be give not to the mechanics of cell division nor the phases but how genetic material passes from parent to offspring. Concepts of recessiveness and dominance. Concept of mapping of phenotype to genes. Discuss about the single gene disorders in humans. Discuss the concept of complementation using human genetics.

Module 4. *(4 hours)-Biomolecules*
Purpose: To convey that all forms of life has the same building blocks and yet the manifestations are as diverse as one can imagine
Molecules of life. In this context discuss monomeric units and polymeric structures. Discuss about sugars, starch and cellulose. Amino acids and proteins. Nucleotides and DNA/RNA. Two carbon units and lipids.

Module 5. *(4 Hours). Enzymes*

Purpose: To convey that without catalysis life would not have existed on earth

Enzymology: How to monitor enzyme catalyzed reactions. How does an enzyme catalyzereactions. Enzyme classification. Mechanism of enzyme action. Discuss at least two examples. Enzyme kinetics and kinetic parameters. Why should we know these parameters to understand biology? RNA catalysis.

Module 6. *(4 hours)- Information Transfer*

Purpose: The molecular basis of coding and decoding genetic information is universal

Molecular basis of information transfer. DNA as a genetic material. Hierarchy of DNA structure- from single stranded to double helix to nucleosomes. Concept of genetic code. Universality and degeneracy of genetic code. Define gene in terms of complementation and recombination.

Module 7. *(5 hours). Macromolecular analysis*

Purpose: How to analyses biological processes at the reductionistic level

Proteins- structure and function. Hierarch in protein structure. Primary secondary, tertiary and quaternary structure. Proteins as enzymes, transporters, receptors and structural elements.

Module 8. *(4 hours)- Metabolism*

Purpose: The fundamental principles of energy transactions are the same in physical and biological world.

Thermodynamics as applied to biological systems. Exothermic and endothermic versus endergonic and exergoinc reactions. Concept of K_{eq} and its relation to standard free energy. Spontaneity. ATP as an energy currency. This should include the breakdown of glucose to CO_2 + H_2O (Glycolysis and Krebs cycle) and synthesis of glucose from CO_2 and H_2O (Photosynthesis). Energy yielding and energy consuming reactions. Concept of Energy charge

Module 9. *(3 hours)- Microbiology*

Concept of single celled organisms. Concept of species and strains. Identification and classification of microorganisms. Microscopy. Ecological aspects of single celled organisms. Sterilization and media compositions. Growth kinetics.

References:

1) Biology: A global approach: Campbell, N. A.; Reece, J. B.; Urry, Lisa; Cain, M, L.; Wasserman, S. A.; Minorsky, P. V.; Jackson, R. B. Pearson Education Ltd
2) Outlines of Biochemistry, Conn, E.E; Stumpf, P.K; Bruening, G; Doi, R.H., John Wiley and Sons
3) Principles of Biochemistry (V Edition), By Nelson, D. L.; and Cox, M. M.W.H. Freeman and Company
4) Molecular Genetics (Second edition), Stent, G. S.; and Calender, R.W.H. Freeman and company, Distributed by Satish Kumar Jain for CBS Publisher
5) Microbiology, Prescott, L.M J.P. Harley and C.A. Klein 1995. 2nd edition Wm, C. Brown Publishers

Course Outcomes

After studying the course, the student will be able to:

- Describe how biological observations of 18th Century that lead to major discoveries.
- Convey that classification *per se* is not what biology is all about but highlight the underlying criteria, such as morphological, biochemical and ecological
- Highlight the concepts of recessiveness and dominance during the passage of genetic material from parent to offspring
- Convey that all forms of life have the same building blocks and yet the manifestations are as diverse as one can imagine
- Classify enzymes and distinguish between different mechanisms of enzyme action.
- Identify DNA as a genetic material in the molecular basis of information transfer.
- Analyse biological processes at the reductionistic level
- Apply thermodynamic principles to biological systems.
- Identify and classify microorganisms.

Elective Courses
Chemistry – II

Chemical Applications	Elective	(4/3 credits)

(i) Polymers (8)

Mechanism of polymerization and synthesis of polymers. Molecular weight, shape and conformation of polymers. Crystallinity, melting point and glass transition. Copolymerization. Viscoelasticity. Elastomers-structure, applications and curing. Conducting polymers and applications. Dendrimers. Solubility of polymers. Fabrication and moulding of polymers. Synthesis, properties and uses of PE, PVC, PMMA, formaldehyde resins, melamine-formaldehyde-urea resins. Adhesives, adhesive mechanism and applications. Composites: characteristics, types and applications. Nanocomposites. Metallic and non-metallic fillers.

(ii) Surfactants and Lubricants (4)

Methods of preparation, cleaning mechanism. Critical micelle concentration and its determination. Hydrophobic and hydrophilic interactions. Micelles and reverse micelles. Detergents. Fricohesity of surfactants. Lubricants-physical and chemical properties, types and mechanism of lubrication. Additives of lubricants and freezing points of lubricants.

(iii) Corrosion (4)

Thermodynamic overview of electrochemical processes. Reversible and irreversible cells. Chemical and electrochemical corrosion and mechanism of corrosion. Factors affecting corrosion. Protection of corrosion and practical problems of corrosion.

(iv) New Materials/Nanomaterials (6)

Nanomaterials. Properties and application of fullerenes, fullerols, carbon nanotubes and nanowires. Synthesis-top down and bottom up approaches. Nanoelectronics. Applications of nanomaterials in catalysis, telecommunication and medicine.

(v) Environmental and green chemistry (6)

Air, water and noise pollution. Optimum levels of pollution. Significance and determination of COD and BOD. Solid waste treatment of collection of NKP. Greenhouse effect and global warming. e-Waste. radioactive pollution. Applications of green chemistry and green technology. Concept of atomic and molecular economy and its use in green chemistry.

(vi) Energy science (6)

Analysis of coal. Petroleum refining, liquid fuels, anti-knock agents. Cracking of oils. Limitations of fossil fuels. Alternative and non-conventional sources of energy – solar, wind, geo, hydro-power and biomass. Advantages and disadvantages. Nuclear energy, reactors and nuclear waste disposal. Safety measures for nuclear reactors. Battery technology. Rechargeable batteries. Fuel cells. Photovoltaics.

(vii) Metals and Alloys (4)

Phase rule and applications to one, two and multi-component systems. Iron-carbon phase diagram. Types of alloys, carbon steel, alloy steel, alloys of Cu, AL, Pb.

(viii) Modern Analytical techniques (4)

Mass spectrometry. Thermal analysis. Electron microscopy, scanning tunneling microscope and atomic force microscope. Sensors. Lab-on-a-chip

Text Books

(1) Introduction to Nanoscience, by S. M. Lindsay
(2) A Textbook of Engineering Chemistry, by Shashi Chawla
(3) Engineering Chemistry, by S. S. Dara
(4) Engineering Chemistry, by P. C Jain and M. Jain
(5) Journal of Biochem. Biophys. Methods, Vol 67 (2006) pp 151-161
(6) International Journal of Environmental and Analytical Chemistry, Vol 91 (2011), pp 272-279
(7) Advanced Polymer Chemistry, by M. Chanda
(8) A Textbook of Environmental Chemistry, by O. D. Tyagi and M. Mehra
(9) Energy Scenario beyond 2100, by S. Muthukrishna Iyer
10) Physical Chemistry of Metals, by L. S. Darken and R. W. Gurry
11) Surfactants and Polymers in Aqueous Solution, by K. Holmberg, B. Jonsson, B. Kronberg and B. Lindman
12) Physical Metallurgy, by R. E. Reed-Hill

Course Outcomes

This course applies the principles studied in Chemistry – I to understand the structures of different types of molecules in various environments. The students will be able distinguish between the structures, reactions and synthesis of polymers, surfactants, lubricants, metals, alloys, colloids and nanomaterials. New analytical techniques will be compared with the classical methods that use gravimetric and volumetric analysis. Chemical analysis of corrosion will be made. Green chemistry, environmental chemistry and non-conventional energy sources will be assessed in the present context.

Polymer Chemistry (Elective)	**2 lectures and 1 tutorial per week**	**3 credits**

This course is an introduction to polymer science that explores synthesis, physical properties and kinetics of polymers/macromolecules. It also explores their conformations and transitions using equilibrium thermodynamics and kinetics.

PREREQUISITES: Chemistry I and Chemistry II of AICTE syllabus

Module 1. Definitions, origin, nomenclature, classification and types of macromolecules; molecular weight (MW) and its distribution; Determination of molecular weight - methods for measuring number average, weight average, viscosity average MW; gel permeation chromatography; spectroscopic techniques to determine chemical composition and molecular microstructure, thermal transitions; melting temperature and glass transition temperature. Colligative properties, osmotic pressure, light scattering, refractive index, viscosity, small angle X-ray scattering (6)

Module 2. Step-Growth Polymerization: Reactivity of functional groups; kinetics; molecular weight in open and closed system cyclization vs. linear polymerization, cross-linking and gel point; process condition; step-copolymerization, examples of step polymers (3)

Module 3. Free radical Polymerization: Nature of chain polymerization and its comparison with step polymerization; radical vs. ionic polymerizations; structural arrangements of monomer units; kinetics of chain polymerization; molecular weight and its distribution; chain transfer, inhibition, retardation, auto-acceleration; energetic characteristics; techniques of radical polymerization – bulk, solution, emulsion, suspension polymerization; examples of polymers made by radical chain polymerization (4)

Module 4. Ionic Polymerization: Propagation and termination of cationic polymerization, anionic and ring opening polymerization, active polycarbanions (2)

Module 5. Copolymerization: types of copolymers, copolymer compositions, reactivity ratio; radical and ionic co-polymerizations; Block and Graft copolymer synthesis, examples (2).

Module 6. Thermodynamics of polymer solutions; Flory-Huggins theory, theta conditions; solubility parameters; fractionation of macromolecules, osmotic pressure, lower critical solution temperature (3)

Module 7. Naturally occurring polymers, biodegradability, biosynthesis, polymers from bio/renewable resources (2)

Module 8. Polymers for Electronics: Polymer resists for integrated circuit fabrication, lithography and photolithography, Electron beam, X-ray and ion sensitive resists,Conducting polymers, types, properties and applications, electroluminescence, molecular basis of electrical conductivity, Photonic applications and non-linear optics, optical information storage (3)

Module 9. Fibers: Polyesters, mechanical requirements for fibers, drawing, orientation and crystallinity, stress strain curves; Carbon fibers and nanotubes, Polymer blends and composites: characteristics, types and applications; Polymer films in sensor applications (3)

Text Books:

1. NPTEL Polymer Chemistry Course, D. Dhara, IIT Kharagpur
2. Polymer chemistry and Physics of Modern Materials, 2nd edn, J. M. G. Cowie, Stanley Thornes, UK, 1998
3. Contemporary Polymer Chemistry, 3rd edn. H. R. Allcock, F. W. Lampe and J. E. Mark, Pearson
4. Polymers: Chemistry and Physics of Modern Materials, J.M.G. Cowie, CRC Press
5. Introduction to Physical Polymer Science, L. H. Sperling, Wiley
6. Introduction to Soft matter, I. W. Hamley, John Wiley and Sons, 2007
7. Polymer Chemistry, 2nd edn, P. C. Hiemenz and T. P. Lodge, CRC Press (2007)
8. Principles of Polymer Chemistry, P. J. Flory, Cornell University Press, 1953

Course Outcomes

- After studying this course, the learners are expected to:
  Relate polymer properties to their structure and conformation
- Analyse different mechanisms of polymer formation and use this information in the synthesis of different polymers.
- Distinguish between enthalpic and entropic contributions to polymerisation/crystallization.
- Distinguish between absolute and relative methods for molecular weight determination.
- Determine the flow properties of polymer melts and solutions.
- Interpret experimental data and determine parameters such as polymerization rates and copolymer composition.
- Estimate the solubility of a given polymer in various solvents and blends.
- Evaluate the effect of factors such as polymer structure, molecular weight, branching and diluents on crystallinity.
- Assess the effect of synthetic polymers on the environment.

Experiments in Polymer Chemistry

Elective (2 Credits; One 4 hour lab per week)

(Since there could be toxic vapours in these experiments, all experiments should be carried out in hoods that can be covered and the students should always wear safety glasses, lab-coats and shoes. Some of these experiments will help in developing good synthetic skills)

1) Measurements of Molecular weights and molecular weight determination of polymers
2) Determination of viscosity of dilute polymeric solutions
3) Measurement of osmotic pressure of polymeric solutions
4) Measurement of elastic constants of elastomers
5) Preparation of nylon films by condensation polymerization
6) Free radical polymerization and characterization of polymethylmethacrylate (PMMA)
7) Free radical block polymerization of styrene
8) Preparation of polystyrene by anionic/cationic/emulsion polymerization method
9) Condensation polymerization of an unsated polyester
10) Preparation of Poly(1,4-butylene isophthalate)

11) Synthesis of a Fluorescent Conjugated polymer, poly[2-methoxy-5-(2ethylhexyloxy)-1,4-phenylenevinylene] (MEH-PPV)
12) Preparation of epoxy resins
13) Experiments on degradation of polymers
14) Structural analysis of polymers by Fourier Transform Infrared (FTIR) Spectroscopy
15) Demonstration of techniques such as gel permeation chromatography, light scattering, optical microscopy, X-ray diffraction, nuclear magnetic resonance and thermogravimetric analysis and differential scanning calorimetry

Suggested References:

1) Polymer synthesis and characterization: A laboratory Manual, S. R. Sandler, W. Caro, J. Bonesteel and E. M. Pearce, Academic Press (1998)
2) Laboratory Procedures in Polymer Chemistry, P. Jannasch, Lund University, http://www.polymat.lth.se/courses/pol_chem/PKEMI_LaboratoryProcedures.pdf
3) C. Duval-Terrie and L. Leburn, J. Chemical Education, 443, **83** (2006)
4) T. Mako and M. Levine, J. Chemical Education, 1376, **90** (2013)

Course Outcomes

The course will help the students to gain hands-on experience in making different polymers, distinguish between different polymer structures, classify polymers and analyse the mechanisms of polymerisation. The uses of polymers in different walks of life will also be appreciated.

Different Modules for Mathematics Courses

Algebra and Trigonometry (Optional)

Module 1a: ***Trigonometry:*** Hyperbolic and circular functions, logarithms of complex number, resolving real and imaginary parts of a complex quantity, De Moivre's Theorem.

Module 1b*: Theory of equations:* Relation between roots and coefficients, reciprocal equations, transformation of equations and diminishing the roots.

BSC103	**Mathematics-I** **(Calculus, Multivariable Calculus & Linear Algebra)**	**3L:1T:0P**	**4 credits**

Calculus (Single Variable)

Module 2a: ***Calculus:*** (6 hours)

Evolutes and involutes; Evaluation of definite and improper integrals; Beta and Gamma functions and their properties; Applications of definite integrals to evaluate surface areas and volumes of revolutions.

Module 2b: ***Calculus:*** (6 hours)

Rolle's theorem, Mean value theorems, Taylor's and Maclaurin theorems with remainders; Indeterminate forms and L'Hospital's rule; Maxima and minima.

Module 2c:*Sequences and series:* (Prerequisite 2b) (10 hours)
Convergence of sequence and series, tests for convergence, power series, Taylor's series. Series for exponential, trigonometric and logarithmic functions; Fourier series: Half range sine and cosine series, Parseval's theorem.

Textbooks/References:

1. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Edition, Pearson, Reprint, 2002.
2. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.
3. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11th Reprint, 2010.
4. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2010.
5. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition, 2000.

Multivariable Calculus

Module 3a:***Multivariable Calculus (Differentiation)*** (Prerequisite 2b) (10 hours)
Limit, continuity and partial derivatives, directional derivatives, total derivative; Tangent plane and normal line; Maxima, minima and saddle points; Method of Lagrange multipliers; Gradient, curl and divergence.

Module 3b: ***Multivariable Calculus (Integration)*** (Prerequisite 3a) (10 hours)
Multiple Integration: double and triple integrals (Cartesian and polar), change of order of integration in double integrals, Change of variables (Cartesian to polar), Applications: areas and volumes by (double integration) Center of mass and Gravity (constant and variable densities). Theorems of Green, Gauss and Stokes, orthogonal curvilinear coordinates, Simple applications involving cubes, sphere and rectangular parallelepipeds.

Textbooks/References:

1. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Edition, Pearson, Reprint, 2002.
2. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.
3. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11th Reprint, 2010.
4. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2010.
5. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition, 2000.

Matrices and Linear Algebra

Module 4a:*Matrices (in case vector spaces is not to be taught)* (14 hours)
Algebra of matrices, Inverse and rank of a matrix, rank-nullity theorem; System of linear equations; Symmetric, skew-symmetric and orthogonal matrices; Determinants; Eigenvalues and eigenvectors; Diagonalization of matrices; Cayley-Hamilton Theorem, Orthogonal transformation and quadratic to canonical forms.

Module 4b:*Matrices (in case vector spaces is to be taught)* (8 hours)
Matrices, vectors: addition and scalar multiplication, matrix multiplication; Linear systems of equations, linear Independence, rank of a matrix, determinants, Cramer's Rule, inverse of a matrix, Gauss elimination and Gauss-Jordan elimination.

Module 4c:*Vector spaces* (Prerequisite 4b) (10 hours)
Vector Space, linear dependence of vectors, basis, dimension; Linear transformations (maps), range and kernel of a linear map, rank and nullity, Inverse of a linear transformation, rank-nullity theorem, composition of linear maps, Matrix associated with a linear map.
Module 4d:*Vector spaces* (Prerequisite 4b-c) (10 hours)

Eigenvalues, eigenvectors, symmetric, skew-symmetric, and orthogonal Matrices, eigenbases. Diagonalization; Inner product spaces, Gram-Schmidt orthogonalization.

Textbooks/References:

1. D. Poole, Linear Algebra: A Modern Introduction, 2nd Edition, Brooks/Cole, 2005.
2. V. Krishnamurthy, V.P. Mainra and J.L. Arora, An introduction to Linear Algebra, Affiliated East–West press, Reprint 2005.
3. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
4. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.
5. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2010.
6. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition, 2000.

BSC104	**Mathematics-II (Differential equations)**	**3L:1T:0P**	**4 credits**

(Prerequisite Sections 2 and 3)
Module 5a:*First order ordinary differential equations*(6 hours)
Exact, linear and Bernoulli's equations, Euler's equations, Equations not of first degree: equations solvable for p, equations solvable for y, equations solvable for x and Clairaut's type.

Module 5b:*Ordinary differential equations of higher orders* (Prerequisite 2c, 4a) (8 hours)
Second order linear differential equations with variable coefficients, method of variation of parameters, Cauchy-Euler equation; Power series solutions; Legendre polynomials, Bessel functions of the first kind and their properties.

Textbooks/References:

1. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
2. W. E. Boyce and R. C. DiPrima, Elementary Differential Equations and Boundary Value Problems, 9th Edition, Wiley India, 2009.
3. S. L. Ross, Differential Equations, 3rd Ed., Wiley India, 1984.
4. E. A. Coddington, An Introduction to Ordinary Differential Equations, Prentice Hall India, 1995.
5. E. L. Ince, Ordinary Differential Equations, Dover Publications, 1958.
6. G.F. Simmons and S.G. Krantz, Differential Equations, Tata McGraw Hill, 2007.

Module 5c:*Partial Differential Equations – First order* (Prerequisite 5a-b) (6 hours)
First order partial differential equations, solutions of first order linear and non-linear PDEs.

Module 5d: ***Partial Differential Equations* – Higher order** (Prerequisite 5b-c) (10 hours)
Solution to homogenous and non-homogenous linear partial differential equations second and higher order by complimentary function and particular integral method.
Flows, vibrations and diffusions, second-order linear equations and their classification, Initial and boundary conditions (with an informal description of well-posed problems), D'Alembert's solution of the wave equation; Duhamel's principle for one dimensional wave equation.
Separation of variables method to simple problems in Cartesian coordinates. The Laplacian in plane, cylindrical and spherical polar coordinates, solutions with Bessel functions and Legendre functions. One dimensional diffusion equation and its solution by separation of variables.
Boundary-value problems: Solution of boundary-value problems for various linear PDEs in various geometries.

Textbooks/References:

1. S. J. Farlow, Partial Differential Equations for Scientists and Engineers, Dover Publications, 1993.
2. R. Haberman, Elementary Applied Partial Differential equations with Fourier Series and Boundary Value Problem, 4th Ed., Prentice Hall, 1998.
3. Ian Sneddon, Elements of Partial Differential Equations, McGraw Hill, 1964.
4. Manish Goyal and N.P. Bali, Transforms and Partial Differential Equations, University Science Press, Second Edition, 2010.

Complex Variables (Prerequisite 2a-c)

Module 6a: ***Complex Variable – Differentiation*** (Prerequisite 2a-c) (8 hours):
Differentiation, Cauchy-Riemann equations, analytic functions, harmonic functions, finding harmonic conjugate; elementary analytic functions (exponential, trigonometric, logarithm) and their properties; Conformal mappings, Mobius transformations and their properties.

Module 6b: ***Complex Variable - Integration***(Prerequisite 6a) (8 hours):
Contour integrals, Cauchy-Goursat theorem (without proof), Cauchy Integral formula (without proof), Liouville's theorem and Maximum-Modulus theorem (without proof); Taylor's series, zeros of analytic functions, singularities, Laurent's series; Residues, Cauchy Residue theorem (without proof), Evaluation of definite integral involving sine and cosine, Evaluation of certain improper integrals using the Bromwich contour.

Module 6c:*Applications of complex integration by residues*: (Prerequisite 2a, 6b) (4 hours)
Evaluation of definite integral involving sine and cosine. Evaluation of certain improper integrals using the Bromwich contour.

Textbooks/References:

1. Erwin kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
2. J. W. Brown and R. V. Churchill, Complex Variables and Applications, 7th Ed., Mc-Graw Hill, 2004.
3. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.
4. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2010.
5. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition, 2000.

Numerical Methods

Module 7a: ***Numerical Methods – 1*** (Prerequisite 2a) (12 hours)
Solution of polynomial and transcendental equations – Bisection method, Newton-Raphson method and Regula-Falsi method. Finite differences, Relation between operators, Interpolation using Newton's forward and backward difference formulae. Interpolation with unequal intervals: Newton's divided difference and Lagrange's formulae. Numerical Differentiation, Numerical integration: Trapezoidal rule and Simpson's 1/3rd and 3/8 rules.

Module 7b: ***Numerical Methods – 2*** (Prerequisite 7a, 5a-d) (10 hours)
Ordinary differential equations: Taylor's series, Euler and modified Euler's methods. Runge-Kutta method of fourth order for solving first and second order equations. Milne's and Adam's predicator-corrector methods.
Partial differential equations: Finite difference solution two dimensional Laplace equation and Poission equation, Implicit and explicit methods for one dimensional heat equation (Bender-Schmidt and Crank-Nicholson methods), Finite difference explicit method for wave equation.

Textbooks/References:

1. P. Kandasamy, K. Thilagavathy, K. Gunavathi, Numerical Methods, S. Chand & Company, 2nd Edition, Reprint 2012.
2. S.S. Sastry, Introductory methods of numerical analysis, PHI, 4th Edition, 2005.
3. Erwin kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
4. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition, 2010.

BSC201	Mathematics-III (Transform & Discrete Mathematics)	2L:1T:0P	2 credits

Transform Calculus

Module 8a: ***Transform Calculus* -1** (Prerequisite 2c, 5b-d, 6b) (10 hours)

Polynomials – Orthogonal Polynomials – Lagrange's, Chebysev Polynomials; Trigonometric Polynomials;

Laplace Transform, Properties of Laplace Transform, Laplace transform of periodic functions. Finding inverse Laplace transform by different methods, convolution theorem. Evaluation of integrals by Laplace transform, solving ODEs and PDEs by Laplace Transform method.

Module 8b:*Transform Calculus*-2 (10 hours)

Fourier transforms, Z-transform and Wavelet transforms: properties, methods, inverses and their applications.

Textbooks/References:

1. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
2. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2010.
3. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition, 2000.
4. Veerarajan T., Engineering Mathematics, Tata McGraw-Hill, New Delhi, 2008.

Discrete Mathematics

Module 9a:*Sets, relations and functions*: (8 hours)

Basic operations on sets, Cartesian products, disjoint union (sum), and power sets. Different types of relations, their compositions and inverses. Different types of functions, their compositions and inverses.

Module 9b:*Propositional Logic:* (6 hours)

Syntax and semantics, proof systems, satisfiability, validity, soundness, completeness, deduction theorem, etc. Decision problems of propositional logic. Introduction to first order logic and first order theory.

Module 9c:*Partially ordered sets:* (6 hours)

Complete partial ordering, chain, lattice, complete, distributive, modular and complemented lattices. Boolean and pseudo Boolean lattices.

Module 9d:*Algebraic Structures:* (6 hours)

Algebraic structures with one binary operation – semigroup, monoid and group. Cosets, Lagrange's theorem, normal subgroup, homomorphic subgroup. Congruence relation and quotient structures. Error correcting code. Algebraic structures with two binary operations- ring, integral domain, and field. Boolean algebra and boolean ring (Definitions and simple examples only).

Module 9e:*Introduction to Counting:*(6 hours)
Basic counting techniques – inclusion and exclusion, pigeon-hole principle, permutation, combination, summations. Introduction to recurrence relation and generating functions.

Module 9f:*Introduction to Graphs:* (8 hours)
Graphs and their basic properties – degree, path, cycle, subgraph, isomorphism, Eulerian and Hamiltonian walk, trees.

Textbooks/References:

1. C. L. Liu, Elements of Discrete Mathematics, 2nd Ed., Tata McGraw-Hill, 2000.
2. R. C. Penner, Discrete Mathematics: Proof Techniques and Mathematical Structures, World Scientific, 1999.
3. R. L. Graham, D. E. Knuth, and O. Patashnik, Concrete Mathematics, 2nd Ed., Addison-Wesley, 1994.
4. K. H. Rosen, Discrete Mathematics and its Applications, 6th Ed., Tata McGraw-Hill, 2007.
5. J. L. Hein, Discrete Structures, Logic, and Computability, 3rd Ed., Jones and Bartlett, 2010.
6. N. Deo, Graph Theory, Prentice Hall of India, 1974.
7. S. Lipschutz and M. L. Lipson, Schaum's Outline of Theory and Problems of Discrete Mathematics, 2nd Ed., Tata McGraw-Hill, 1999.
8. J. P. Tremblay and R. P. Manohar, Discrete Mathematics with Applications to Computer Science, Tata McGraw-Hill, 1997.

MATHEMATICS-IV (OPTIONAL)
Probability Theory and Statistics

Probability Theory

Module 10a: Basic Probability: (12 hours)
Probability spaces, conditional probability, independence; Discrete random variables, Independent random variables, the multinomial distribution, Poisson approximation to the binomial distribution, infinite sequences of Bernoulli trials, sums of independent random variables; Expectation of Discrete Random Variables, Moments, Variance of a sum, Correlation coefficient, Chebyshev's Inequality.

Module 10b: Continuous Probability Distributions: (4 hours)
Continuous random variables and their properties, distribution functions and densities, normal, exponential and gamma densities.

Module 10c: Bivariate Distributions: (4 hours)
Bivariate distributions and their properties, distribution of sums and quotients, conditional densities, Bayes' rule.

Textbooks/References:

1. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
2. P. G. Hoel, S. C. Port and C. J. Stone, Introduction to Probability Theory, Universal Book Stall, 2003 (Reprint).

3. S. Ross, A First Course in Probability, 6th Ed., Pearson Education India, 2002.
4. W. Feller, An Introduction to Probability Theory and its Applications, Vol. 1, 3rd Ed., Wiley, 1968.

Statistics

Module 10d: Basic Statistics: (8 hours)

Measures of Central tendency: Moments, skewness and Kurtosis - Probability distributions: Binomial, Poisson and Normal - evaluation of statistical parameters for these three distributions, Correlation and regression – Rank correlation.

Module 10e: Applied Statistics: (8 hours)

Curve fitting by the method of least squares- fitting of straight lines, second degree parabolas and more general curves. Test of significance: Large sample test for single proportion, difference of proportions, single mean, difference of means, and difference of standard deviations.

Module 10f: Small samples: (4 hours)

Test for single mean, difference of means and correlation coefficients, test for ratio of variances - Chi-square test for goodness of fit and independence of attributes.

Textbooks/References:

1. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
2. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2010.
3. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition, 2000.
4. Veerarajan T., Engineering Mathematics (for semester III), Tata McGraw-Hill, New Delhi, 2010.

BSC225	**Life Science**	**1L:0T:2P**	**2 credits**

Module 1A: *Plant Physiology* covering, Transpiration; Mineral nutrition *(3 Lectures)*

Module 1B: *Ecology* covering, Ecosystems- Components, types, flow of matter and energy in an ecosystem; Community ecology- Characteristics, frequency, life forms, and biological spectrum; Ecosystem structure- Biotic and a-biotic factors, food chain, food web, ecological pyramids; *(3 Lectures)*

Module 2A: *Population Dynamics* covering, Population ecology- Population characteristics, ecotypes; Population genetics- Concept of gene pool and genetic diversity in populations, polymorphism and heterogeneity; *(3 Lectures)*

Module 2B*: Environmental Management* covering, Principles: Perspectives, concerns and management strategies; Policies and legal aspects- Environment Protection Acts and modification, International Treaties; Environmental Impact Assessment- Case studies (International Airport, thermal power plant); *(3 Lectures)*

Module 3A*:* *Molecular Genetics* covering, Structures of DNA and RNA; Concept of Gene, Gene regulation, e.g., Operon concept; *(3 Lectures)*

Module 3B*: Biotechnology* covering, Basic concepts: Totipotency and Cell manipulation; Plant & Animal tissue culture- Methods and uses in agriculture, medicine and health; Recombinant DNA Technology- Techniques and applications; *(3 Lectures)*

Module 4A: *Biostatistics* covering, Introduction to Biostatistics:-Terms used, types of data; Measures of Central Tendencies- Mean, Median, Mode, Normal and Skewed distributions; Analysis of Data- Hypothesis testing and ANNOVA (single factor) *(4 Lectures)*

Module 5 : *Laboratory & Fieldwork Sessions* covering, Comparison of stomatal index in different plants; Study of mineral crystals in plants; Determination of diversity indices in plant communities; To construct ecological pyramids of population sizes in an ecosystem; Determination of Importance Value Index of a species in a plant community; Seminar (with PPTs) on EIA of a Mega-Project (e.g., Airport, Thermal/Nuclear Power Plant/ Oil spill scenario); Preparation and extraction of genomic DNA and determination of yield by UV absorbance; Isolation of Plasmid DNA and its separation by Gel Electrophoresis; Data analysis using Bio-statistical tools; *(15 Sessions)*

Text/Reference Books:

1. Biology: A global approach: Campbell, N. A.; Reece, J. B.; Urry, Lisa; Cain, M, L.; Wasserman, S. A.; Minorsky, P. V.; Jackson, R. B. Pearson Education Ltd
2. Outlines of Biochemistry, Conn, E.E; Stumpf, P.K; Bruening, G; Doi, R.H. John Wiley and Sons
3. Principles of Biochemistry (V Edition), By Nelson, D. L.; and Cox, M. M.W.H. Freeman and Company
4. Molecular Genetics (Second edition), Stent, G. S.; and Calender, R. W.H. Freeman and company, Distributed by Satish Kumar Jain for CBS Publisher
5. Microbiology, Prescott, L.M J.P. Harley and C.A. Klein 1995. 2nd edition Wm, C. Brown Publishers

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3.3 ENGINEERING SCIENCE COURSES

ESC 101	Basic Electrical Engineering	3L:1T:2P	5 credits

Teaching Scheme:(Lectures - 3 hours/ week; Tutorial - 1 hour/week; Laboratory – 2 hours/week)

Course Outcomes

- To understand and analyze basic Electric and Magnetic circuits
- To study the working principles of Electrical Machines and Power Converters.
- To introduce components of Low Voltage Electrical Installations

Unit 1: D.C. Circuits (8 lectures)

Electrical circuit elements (R, L and C), voltage and current sources, Kirchoff current and voltage laws, analysis of simple circuits with dc excitation. Superposition, Thevenin and Norton Theorems.

Time-domain analysis of first-order RL and RC circuits.

Unit2: A.C. Circuits (8 lectures)

Representation of sinusoidal waveforms, peak and rms values, phasor representation, real power, reactive power, apparent power, power factor,

Analysis of single-phase ac circuits consisting of R, L, C, RL, RC, RLC combinations (series and parallel), resonance.

Three-phase balanced circuits, voltage and current relations in star and delta connections.

Unit3: Transformers (6 lectures)

Magnetic materials, BH characteristics, ideal and practical transformer, equivalent circuit, losses in transformers, regulation and efficiency.

Auto-transformer and three-phase transformer connections.

Unit4: Electrical Machines (8 lectures)

Generation of rotating magnetic fields, Construction and working of a three-phase induction motor, Significance of torque-slip characteristic. Loss components and efficiency, starting and speed control of induction motor. Single-phase induction motor.

Construction, working, torque-speed characteristic and speed control of separately excited dc motor.

Construction and working of synchronous generators.

Unit 5: Power Converters (6 lectures)

DC-DC buck and boost converters, duty ratio control.

Single-phase and three-phase voltage source inverters; sinusoidal modulation.

Unit 6: Electrical Installations (6 lectures)

Components of LT Switchgear: Switch Fuse Unit (SFU), MCB, ELCB, MCCB, Types of Wires and Cables, Earthing. Types of Batteries, Important Characteristics for Batteries.

Elementary calculations for energy consumption, power factor improvement and battery backup.

List of Laboratory Experiments/Demonstrations:

1. Basic safety precautions. Introduction and use of measuring instruments – voltmeter, ammeter, multi-meter, oscilloscope. Real-life resistors, capacitors and inductors.
2. Measuring the steady-state and transient time-response of R-L, R-C, and R-L-C circuits to a step change in voltage (transient may be observed on a storage oscilloscope). Sinusoidal steady state response of R-L, and R-C circuits – impedance calculation and verification. Observation of phase differences between current and voltage. Resonance in R-L-C circuits.
3. Transformers: Observation of the no-load current waveform on an oscilloscope (non-sinusoidal wave-shape due to B-H curve nonlinearity should be shown along with a discussion about harmonics). Loading of a transformer: measurement of primary and secondary voltages and currents, and power.
4. Three-phase transformers: Star and Delta connections. Voltage and Current relationships (line-line voltage, phase-to-neutral voltage, line and phase currents). Phase-shifts between the primary and secondary side. Cumulative three-phase power in balanced three-phase circuits.
5. Demonstration of cut-out sections of machines: dc machine (commutator-brush arrangement), induction machine (squirrel cage rotor), synchronous machine (field winging - slip ring arrangement) and single-phase induction machine.
6. Torque Speed Characteristic of separately excited dc motor.
7. Synchronous speed of two and four-pole, three-phase induction motors. Direction reversal by change of phase-sequence of connections. Torque-Slip Characteristic of an induction motor. Generator operation of an induction machine driven at super-synchronous speed.
8. Synchronous Machine operating as a generator: stand-alone operation with a load. Control of voltage through field excitation.
9. Demonstration of (a) dc-dc converters (b) dc-ac converters – PWM waveform (c) the use of dc-ac converter for speed control of an induction motor and (d) Components of LT switchgear.

Text-Books/Reference-Books:

1) Basic Electrical Engineering - D.P. Kothari and I.J. Nagrath, 3rd edition 2010, Tata McGraw Hill.
2) Basic Electrical Engineering - D.C. Kulshreshtha, 2009, Tata McGraw Hill.
3) Fundamentals of Electrical Engineering, L.S. Bobrow, Oxford University Press, 2011
4) Electrical and Electronics Technology, E. Hughes, 10th Edition, Pearson, 2010
5) Electrical Engineering Fundamentals, Vincent Deltoro, Second Edition, Prentice Hall India, 1989

Laboratory Outcomes:

The students are expected to

- Get an exposure to common electrical components and their ratings.
- Make electrical connections by wires of appropriate ratings.
- Understand the usage of common electrical measuring instruments.
- Understand the basic characteristics of transformers and electrical machines.
- Get an exposure to the working of power electronic converters.

ESC102	Programming for Problem Solving	3L:0T:4P	5 credits

Course Outcomes:

The course will enable the students

- To formulate simple algorithms for arithmetic and logical problems
- To translate the algorithms to programs (in C language)
- To test and execute the programs and correct syntax and logical errors
- To implement conditional branching, iteration and recursion
- To decompose a problem into functions and synthesize a complete program using divide and conquer approach
- To use arrays, pointers and structures to formulate algorithms and programs
- To apply programming to solve matrix addition and multiplication problems and searching and sorting problems
- To apply programming to solve simple numerical method problems, namely rot finding of function, differentiation of function and simple integration

Unit 1: Introduction to Programming (2 hrs)
Introduction to Programming (Flow chart/pseudocode, compilation etc.), Variables (including data types)

Unit 2: Arithmetic expressions and precedence (2 hrs)
Unit 2: Conditional Branching and Loops (8 hrs)
Writing and evaluation of conditionals and consequent branching
Iteration and loops

Unit 3: Arrays (6 hrs)
Arrays (1-D, 2-D), Character arrays and Strings

Unit 4: Basic Algorithms (6 hrs)
Searching, Basic Sorting Algorithms, Finding roots of equations, idea of time complexity

Unit 5: Function and Recursion (8 hrs)
Functions (including using built in libraries), Recursion with example programs such as Quick sort, Ackerman function etc.

Unit 6: Structure and Pointers (6 hrs)
Pointers, Structures (including self referential structures e.g., linked list, notional introduction)

Unit 7: File handling (2 hrs)

Tutorial and Lab: (total 4 contact hours per week) (outline of topics

Tutorial 1: Problem solving using computers: Lab1: Familiarization with programming environment

Tutorial 2: Variable types and type conversions: Lab 2: Simple computational problems using arithmetic expressions
Tutorial 3: Branching and logical expressions: Lab 3: Problems involving if-then-else structures
Tutorial 4: Loops, while and for loops: Lab 4: Iterative problems e.g., sum of series
Tutorial 5: 1D Arrays: searching, sorting: Lab 5: 1D Array manipulation
Tutorial 6: 2D arrays and Strings, memory structure: Lab 6: Matrix problems, String operations
Tutorial 7: Functions, call by value: Lab 7: Simple functions
Tutorial 8 &9: Numerical methods (Root finding, numerical differentiation, numerical integration): Lab 8 and 9: Numerical methods problems
Tutorial 10: Recursion, structure of recursive calls: Lab 10: Recursive functions
Tutorial 11: Pointers, structures and dynamic memory allocation Lab 11: Pointers and structures
Tutorial 12: File handling: Lab 12: File operations

Textbooks:
1. Byron Gottfried, Schaum's Outline of Programming with C, McGraw-Hill
2. E. Balaguruswamy, Programming in ANSI C, Tata McGraw-Hill

Reference Books:
1. Brian W. Kernighan and Dennis M. Ritchie, The C Programming Language, Prentice Hall of India

Laboratory Outcomes
- To formulate the algorithms for simple problems
- To translate given algorithms to a working and correct program
- To be able to correct syntax errors as reported by the compilers
- To be able to identify and correct logical errors encountered at run time
- To be able to write iterative as well as recursive programs
- To be able to represent data in arrays, strings and structures and manipulate them through a program
- To be able to declare pointers of different types and use them in defining self referential structures.
- To be able to create, read and write to and from simple text files.

ESC104	**Workshop Manufacturing Practices**	**1L:0T:4P**	**3 credits**

Manufacturing is fundamental to the development of any engineering product. This course is intended to expose engineering students to different types of manufacturing/ fabrication processes, dealing with different materials such as metals, ceramics, plastics, wood, glass etc. While the actual practice of fabrication techniques is given more weightage, some lectures and video clips available on different methods of manufacturing are also included. The course intends to prepare students for:

- Understanding different manufacturing techniques and their relative advantages/ disadvantages with respect to different applications
- The selection of a suitable technique for meeting a specific fabrication need
- Acquire a minimum practical skill with respect to the different manufacturing methods and develop the confidence to design & fabricate small components for their project work and also to participate in various national and international technical competitions.

The chief goals of the course are:

- Introduction to different manufacturing methods in different fields of engineering
- Practical exposure to different fabrication techniques
- Creation of simple components using different materials
- Exposure to some of the advanced and latest manufacturing techniques being employed in the industry

Lectures & videos: (10 hours)

1. Manufacturing Methods- casting, forming, machining, joining, advanced manufacturing methods (3 lectures)
2. CNC machining, Additive manufacturing (1 lecture)
3. Fitting operations & power tools (1 lecture)
4. Electrical & Electronics (1 lecture)
5. Carpentry (1 lecture)
6. Plastic moulding, glass cutting (1 lecture)
7. Metal casting (1 lecture)
8. Welding (arc welding & gas welding), brazing (1 lecture)

[More hours can be given to Welding for Civil Engineering students as they may have to deal with Steel structures fabrication and erection; 3D Printing is an evolving manufacturing technology and merits some lectures and hands-on training.]

Suggested Text/Reference Books:

(i) Hajra Choudhury S.K., Hajra Choudhury A.K. and Nirjhar Roy S.K., “Elements of Workshop Technology”, Vol. I 2008 and Vol. II 2010, Media promoters and publishers private limited, Mumbai.
(ii) Kalpakjian S. And Steven S. Schmid, “Manufacturing Engineering and Technology”, 4th edition, Pearson Education India Edition, 2002.
(iii) Gowri P. Hariharan and A. Suresh Babu,”Manufacturing Technology – I” Pearson Education, 2008.
(iv) Roy A. Lindberg, “Processes and Materials of Manufacture”, 4th edition, Prentice Hall India, 1998.
(v) Rao P.N., “Manufacturing Technology”, Vol. I and Vol. II, Tata McGrawHill House, 2017.

Course Outcomes

Upon completion of this course, the students will gain knowledge of the different manufacturing processes which are commonly employed in the industry, to fabricate components using different materials.

Workshop Practice: **(60 hours)**

1. Machine shop - 10 hours
2. Fitting shop - 8 hours
3. Carpentry - 6 hours
4. Electrical & Electronics - 8 hours
5. Welding shop - 8 hours (Arc welding 4 hrs + gas welding 4 hrs)
6. Casting - 8 hours
7. Smithy - 6 hours
8. Plastic moulding & Glass Cutting -6 hours

Examinations could involve the actual fabrication of simple components, utilizing one or more of the techniques covered above.

Laboratory Outcomes

- Upon completion of this laboratory course, students will be able to fabricate components with their own hands.
- They will also get practical knowledge of the dimensional accuracies and dimensional tolerances possible with different manufacturing processes.
- By assembling different components, they will be able to produce small devices of their interest.

ESC105	Engineering Graphics & Design	1L:0T:4P	3 credits

All phases of manufacturing or construction require the conversion of new ideas and design concepts into the basic line language of graphics. Therefore, there are many areas (civil, mechanical, electrical, architectural and industrial) in which the skills of the CAD technicians play major roles in the design and development of new products or construction. Students prepare for actual work situations through practical training in a new state-of-the-art computer designed CAD laboratory using engineering software. This course is designed to address:

- to prepare you to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- to prepare you to communicate effectively
- to prepare you to use the techniques, skills, and modern engineering tools necessary for engineering practice

Proposed Syllabus

Traditional Engineering Graphics: Principles of Engineering Graphics; Orthographic Projection; Descriptive Geometry; Drawing Principles; Isometric Projection; Surface Development; Perspective; Reading a Drawing; Sectional Views; Dimensioning & Tolerances; True Length, Angle; intersection, Shortest Distance.

Computer Graphics: Engineering Graphics Software; -Spatial Transformations; Orthographic Projections; Model Viewing; Co-ordinate Systems; Multi-view Projection; Exploded Assembly; Model Viewing; Animation; Spatial Manipulation; Surface Modelling; Solid Modelling; Introduction to Building Information Modelling (BIM)

TOTAL OF 10 LECTURE HOURS & 60 HOURS OF LAB

(Except the basic essential concepts, most of the teaching part can happen concurrently in the laboratory)

Module 1: Introduction to Engineering Drawing covering, Principles of Engineering Graphics and their significance, usage of Drawing instruments, lettering, Conic sections including the Rectangular Hyperbola (General method only); Cycloid, Epicycloid, Hypocycloid and Involute; Scales – Plain, Diagonal and Vernier Scales;

Module 2: Orthographic Projections covering, Principles of Orthographic Projections-Conventions - Projections of Points and lines inclined to both planes; Projections of planes inclined Planes - Auxiliary Planes;

Module 3: Projections of Regular Solids covering, those inclined to both the Planes-Auxiliary Views; Draw simple annotation, dimensioning and scale. Floor plans that include: windows, doors, and fixtures such as WC, bath, sink, shower, etc.

Module 4: Sections and Sectional Views of Right Angular Solids covering, Prism, Cylinder, Pyramid, Cone – Auxiliary Views; Development of surfaces of Right Regular Solids - Prism, Pyramid, Cylinder and Cone; Draw the sectional orthographic views of geometrical solids, objects from industry and dwellings (foundation to slab only)

Module 5: Isometric Projections covering, Principles of Isometric projection – Isometric Scale, Isometric Views, Conventions; Isometric Views of lines, Planes, Simple and compound Solids; Conversion of Isometric Views to Orthographic Views and Vice-versa, Conventions;

Module 6: Overview of Computer Graphics covering, listing the computer technologies that impact on graphical communication, Demonstrating knowledge of the theory of CAD software [such as: The Menu System, Toolbars (Standard, Object Properties, Draw, Modify and Dimension), Drawing Area (Background, Crosshairs, Coordinate System), Dialog boxes and windows, Shortcut menus (Button Bars), The Command Line (where applicable), The Status Bar, Different methods of zoom as used in CAD, Select and erase objects.; Isometric Views of lines, Planes, Simple and compound Solids];

Module 7: Customisation & CAD Drawing consisting of set up of the drawing page and the printer, including scale settings, Setting up of units and drawing limits; ISO and ANSI standards for coordinate dimensioning and tolerancing; Orthographic constraints, Snap to objects manually and automatically; Producing drawings by using various coordinate input entry methods to draw straight lines, Applying various ways of drawing circles;

Module 8: Annotations, layering & other functions covering applying dimensions to objects, applying annotations to drawings; Setting up and use of Layers, layers to create drawings, Create, edit and use customized layers; Changing line lengths through modifying existing lines (extend/lengthen); Printing documents to paper using the print command; orthographic projection techniques; Drawing sectional views of composite right regular geometric solids and project the true shape of the sectioned surface; Drawing annotation, Computer-aided design (CAD) software modeling of parts and assemblies. Parametric and non-parametric solid, surface, and wireframe models. Part editing and two-dimensional documentation of models. Planar projection theory, including sketching of perspective, isometric, multiview, auxiliary, and section views. Spatial visualization exercises. Dimensioning guidelines, tolerancing techniques; dimensioning and scale multi views of dwelling;

Module 9: Demonstration of a simple team design project that illustrates Geometry and topology of engineered components: creation of engineering models and their presentation in standard 2D blueprint form and as 3D wire-frame and shaded solids; meshed topologies for engineering analysis and tool-path generation for component manufacture; geometric dimensioning and tolerancing; Use of solid-modeling software for creating associative models at the component and assembly levels; floor plans that include: windows, doors, and fixtures such as WC, bath, sink, shower, etc. Applying colour coding according to building drawing practice; Drawing sectional elevation showing foundation to ceiling; Introduction to Building Information Modelling (BIM).

Text/Reference Books:

1. Bhatt N.D., Panchal V.M. & Ingle P.R., (2014), Engineering Drawing, Charotar Publishing House
2. Shah, M.B. & Rana B.C. (2008), Engineering Drawing and Computer Graphics, Pearson Education
3. Agrawal B. & Agrawal C. M. (2012), Engineering Graphics, TMH Publication
4. Narayana, K.L. & P Kannaiah (2008), Text book on Engineering Drawing, Scitech Publishers
5. (Corresponding set of) CAD Software Theory and User Manuals

Goals & Outcomes:

- Introduction to engineering design and its place in society
- Exposure to the visual aspects of engineering design
- Exposure to engineering graphics standards
- Exposure to solid modelling
- Exposure to computer-aided geometric design
- Exposure to creating working drawings
- Exposure to engineering communication

ESC202	Basic Electronics	1L:0T:2P	2 credits

The objective of this Course is to provide the students with an introductory and broad treatment of the field of *Electronics Engineering to facilitate better understanding of the devices, instruments and sensors used in Civil Engineering applications.* Lab should be taken concurrently. This course emphasizes more on the laboratory/practical use of the knowledge gained from the course lectures.

What Will I Learn?

a) Know broadly the concepts and functionalities of the electronic devices, tools and instruments
b) Understand use, general specifications and deployabilities of the electronic devices, and assemblies
c) Confidence in handling and usage of electronic devices, tools and instruments in engineering applications

Proposed Syllabus (All modules to provide only broad overview)
Module1: *Diodes and Applications* covering, Semiconductor Diode - Ideal versus Practical, Resistance Levels, Diode Equivalent Circuits, Load Line Analysis; Diode as a Switch, Diode as a Rectifier, Half Wave and Full Wave Rectifiers with and without Filters; Breakdown Mechanisms, Zener Diode – Operation and Applications; Opto-Electronic Devices – LEDs, Photo Diode and Applications; Silicon Controlled Rectifier (SCR) – Operation, Construction, Characteristics, Ratings, Applications;

Module 2*: Transistor Characteristics* covering, Bipolar Junction Transistor (BJT) – Construction, Operation, Amplifying Action, Common Base, Common Emitter and Common Collector Configurations, Operating Point, Voltage Divider Bias Configuration; Field Effect Transistor (FET) – Construction, Characteristics of Junction FET, Depletion and Enhancement type Metal Oxide Semiconductor (MOS) FETs, Introduction to CMOS circuits;

Module 3*: Transistor Amplifiers and Oscillators* covering, Classification, Small Signal Amplifiers – Basic Features, Common Emitter Amplifier, Coupling and Bypass Capacitors, Distortion, AC Equivalent Circuit; Feedback Amplifiers – Principle, Advantages of Negative Feedback, Topologies, Current Series and Voltage Series Feedback Amplifiers; Oscillators – Classification, RC Phase Shift, Wien Bridge, High Frequency LC and Non-Sinusoidal type Oscillators;

Module 4*: Operational Amplifiers and Applications* covering, Introduction to Op-Amp, Differential Amplifier Configurations, CMRR, PSRR, Slew Rate; Block Diagram, Pin Configuration of 741 Op-Amp, Characteristics of Ideal OpAmp, Concept of Virtual Ground;

Practicals:
Module 1: Laboratory Sessions covering, Identification, Specifications, Testing of R, L, C Components (Colour Codes), Potentiometers, Switches (SPDT, DPDT and DIP), Bread Boards and Printed Circuit Boards (PCBs); Identification, Specifications, Testing of Active Devices – Diodes, BJTs, JFETs, MOSFETs, Power Transistors, SCRs and LEDs;

Module 2: Study and Operation of Digital Multi Meter, Function / Signal Generator, Regulated Power Supply (RPS), Cathode Ray Oscilloscopes; Amplitude, Phase and Frequency of Sinusoidal Signals using Lissajous Patterns on CRO; (CRO);

Module 3: Experimental Verification of PN Junction Diode Characteristics in A) Forward Bias B) Reverse Bias, Zener Diode Characteristics and Zener Diode as Voltage Regulator, Input and Output Characteristics of BJT in Common Emitter (CE) Configuration, Drain and Transfer Characteristics of JFET in Common Source (CS) Configuration;

Module 4: Study of Half Wave and Full Wave Rectification, Regulation with Filters, Gain and Bandwidth of BJT Common Emitter (CE) Amplifier, Gain and Bandwidth of JFET Common Source (CS) Amplifier, Gain and Bandwidth of BJT Current Series and Voltage Series Feedback Amplifiers, Oscillation Frequency of BJT based RC Phase Shift, Hartley and Colpitts Oscillators; Module 5: Op-Amp Applications – Adder, Subtractor, Voltage Follower and Comparator; Op-Amp Applications – Differentiator and Integrator, Square Wave and Triangular Wave Generation, Applications of 555 Timer – Astable and Monostable Multivibrators;

Module 6: Truth Tables and Functionality of Logic Gates – NOT, OR, AND, NOR, NAND, XOR and XNOR Integrated Circuits (ICs); Truth Tables and Functionality of Flip-Flops – SR, JK and D Flip-Flop ICs; Serial-In-Serial-Out and Serial-In-Parallel-Out Shift operations using 4-bit/8-bit Shift Register ICs; Functionality of Up-Down / Decade Counter ICs; (15 Sessions)

Text/Reference Books:

1. David. A. Bell (2003), *Laboratory Manual for Electronic Devices and Circuits*, Prentice Hall, India
2. Santiram Kal (2002), Basic Electronics- Devices, Circuits and IT Fundamentals, Prentice Hall, India
3. Thomas L. Floyd and R. P. Jain (2009), *Digital Fundamentals* by Pearson Education,
4. Paul B. Zbar, A.P. Malvino and M.A. Miller (2009), *Basic Electronics – A Text-Lab. Manual,* TMH
5. R. T. Paynter (2009), *Introductory Electronic Devices & Circuits, Conventional Flow Version,* Pearson

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ESC203	Computer-aided Civil Engineering Drawing	1L:0T:2P	2 credits

The students will be able to

a) Develop Parametric design and the conventions of formal engineering drawing
b) Produce and interpret 2D & 3D drawings
c) Communicate a design idea/concept graphically/ visually
d) Examine a design critically and with understanding of CAD - The student learn to interpret drawings, and to produce designs using a combination of 2D and 3D software.
e) Get a Detailed study of an engineering artifact

ProposedSyllabus (No. of lectures shown within brackets)

Module 1:*INTRODUCTION***;** Introduction to concept of drawings, Interpretation of typical drawings, Planning drawings to show information concisely and comprehensively; optimal layout of drawings and Scales; Introduction to computer aided drawing, co-ordinate systems, reference planes. Commands: Initial settings, Drawing aids, Drawing basic entities, Modify commands, Layers, Text and Dimensioning, Blocks. Drawing presentation norms and standards.(2)

Module 2:*SYMBOLS AND SIGN CONVENTIONS*: Materials, Architectural, Structural, Electrical and Plumbing symbols. Rebar drawings and structural steel fabrication and connections drawing symbols, welding symbols; dimensioning standards (2)

Module 3: *MASONRY BONDS:*English Bond and Flemish Bond – Corner wall and Cross walls - One brick wall and one and half brick wall (1)

Module 4: *BUILDING DRAWING*: Terms, Elements of planning building drawing, Methods of making line drawing and detailed drawing. Site plan, floor plan, elevation and section drawing of small residential buildings. Foundation plan. Roof drainage plans. Depicting joinery, standard fittings & fixtures, finishes. Use of Notes to improve clarity (7)

Module 5:*PICTORIAL VIEW*: Principles of isometrics and perspective drawing. Perspective view of building. Fundamentals of Building Information Modelling (BIM) (3)
Total 15 sessions

It may be advisable to conduct Theory sessions along with Lab demonstrations.

List of Drawing Experiments:

1. Buildings with load bearing walls including details of doors and windows. 09
2. Taking standard drawings of a typical two storeyed building including all MEP, joinery, rebars, finishing and other details and writing out a description of the Facility in about 500 -700 words. 06

3.	RCC framed structures	09
4.	Reinforcement drawings for typical slabs, beams, columns and spread footings.	09
5.	Industrial buildings - North light roof structures - Trusses	06
6.	Perspective view of one and two storey buildings	06

Total L: 15 + P: 45=60

Text/Reference Books:

1. Subhash C Sharma & Gurucharan Singh (2005), “Civil Engineering Drawing”, Standard Publishers
2. Ajeet Singh (2002), “Working with AUTOCAD 2000 with updates on AUTOCAD 200I”, Tata- Mc Graw-Hill Company Limited, New Delhi
3. Sham Tickoo Swapna D (2009), “AUTOCAD for Engineers and Designers”, Pearson Education,
4. Venugopal (2007), “Engineering Drawing and Graphics + AUTOCAD”, New Age International Pvt. Ltd.,
5. Balagopal and Prabhu (1987), “Building Drawing and Detailing”, Spades publishing KDR building, Calicut,
6. (Corresponding set of) CAD Software Theory and User Manuals.
7. Malik R.S., Meo, G.S. (2009) Civil Engineering Drawing, Computech Publication Ltd New Asian.
8. Sikka, V.B. (2013), A Course in Civil Engineering Drawing, S.K.Kataria& Sons,

Goals & Outcomes:

The course should enable the students to

- i) To develop graphical skills for communicating concepts, ideas and designs of engineering products graphically/ visually as well as understand another person’s designs,
- ii) and to get exposure to national standards relating to technical drawings using Computer Aided Design and Drafting practice
- iii) Develop Parametric design and the conventions of formal engineering drawing
- iv) Produce and interpret 2D & 3D drawings
- v) Examine a design critically and with understanding of CAD - The student learn to interpret drawings, and to produce designs using a combination of 2D and 3D software.
- vi) Do a detailed study of an engineering artefact
- vii) Develop drawings for conventional structures using practical norms.

ESC205	Engineering Mechanics	3L:1T:0P	4 credits

The objective of this Course is to provide an introductory treatment of *Engineering Mechanics* to all the students of engineering, with a view to prepare a good foundation for taking up advanced courses in the area in the subsequent semesters. A working knowledge of statics with emphasis on force equilibrium and free body diagrams. Provides an understanding of the kinds of stress and deformation and how to determine them in a wide range of simple, practical structural problems, and an understanding of the mechanical behavior of materials under various load conditions. Lab should be taken concurrently

What Will I Learn?

a) Confidently tackle equilibrium equations, moments and inertia problems
b) Master calculator/computing basic skills to use to advantage in solving mechanics problems.
c) Gain a firm foundation in Engineering Mechanics for furthering the career in Engineering

Proposed Syllabus

Module 1*:* *Introduction to Engineering Mechanics covering,* Force SystemsBasic concepts, Particle equilibrium in 2-D & 3-D; Rigid Body equilibrium; System of Forces, Coplanar Concurrent Forces, Components in Space – Resultant- Moment of Forces and its Application; Couples and Resultant of Force System, Equilibrium of System of Forces, Free body diagrams, Equations of Equilibrium of Coplanar Systems and Spatial Systems; Static Indeterminancy

Module 2*:* *Friction covering,* Types of friction, Limiting friction, Laws of Friction, Static and Dynamic Friction; Motion of Bodies, wedge friction, screw jack & differential screw jack;

Module 3*:* *Basic Structural Analysis covering,* Equilibrium in three dimensions; Method of Sections; Method of Joints; How to determine if a member is in tension or compression; Simple Trusses; Zero force members; Beams & types of beams; Frames & Machines;

Module 4*:* *Centroid and Centre of Gravity covering,* Centroid of simple figures from first principle, centroid of composite sections; Centre of Gravity and its implications; Area moment of inertia- Definition, Moment of inertia of plane sections from first principles, Theorems of moment of inertia, Moment of inertia of standard sections and composite sections; Mass moment inertia of circular plate, Cylinder, Cone, Sphere, Hook.

Module 5*:* *Virtual Work and Energy Method-* Virtual displacements, principle of virtual work for particle and ideal system of rigid bodies, degrees of freedom. Active force diagram, systems with friction, mechanical efficiency. Conservative forces and potential energy (elastic and gravitational), energy equation for equilibrium. Applications of energy method for equilibrium. Stability of equilibrium.

Module 6*:* *Review of particle dynamics-* Rectilinear motion; Plane curvilinear motion (rectangular, path, and polar coordinates). 3-D curvilinear motion; Relative and constrained motion; Newton's 2nd law (rectangular, path, and polar coordinates). Work-kinetic energy, power, potential energy.Impulse-momentum (linear, angular); Impact (Direct and oblique).

Module 7:*Introduction to Kinetics of Rigid Bodies covering,* Basic terms, general principles in dynamics; Types of motion, Instantaneous centre of rotation in plane motion and simple problems; D'Alembert's principle and its applications in plane motion and connected bodies; Work energy principle and its application in plane motion of connected bodies; Kinetics of rigid body rotation;

Module 8:*Mechanical Vibrations covering,* Basic terminology, free and forced vibrations, resonance and its effects; Degree of freedom; Derivation for frequency and amplitude of free vibrations without damping and single degree of freedom system, simple problems, types of pendulum, use of simple, compound and torsion pendulums;

Tutorials*from the above modules covering*, To find the various forces and angles including resultants in various parts of wall crane, roof truss, pipes, etc.; To verify the line of polygon on various forces; To find coefficient of friction between various materials on inclined plan; Free body diagrams various systems including block-pulley; To verify the principle of moment in the disc apparatus; Helical block; To draw a load efficiency curve for a screw jack

Text/Reference Books:

1. Irving H. Shames (2006), Engineering Mechanics, 4th Edition, Prentice Hall
2. F. P. Beer and E. R. Johnston (2011), Vector Mechanics for Engineers, Vol I - Statics, Vol II, – Dynamics, 9th Ed, Tata McGraw Hill
3. R. C. Hibbler (2006), Engineering Mechanics: Principles of Statics and Dynamics, Pearson Press.
4. Andy Ruina and Rudra Pratap (2011), Introduction to Statics and Dynamics, Oxford University Press
5. Shanes and Rao (2006), Engineering Mechanics, Pearson Education,
6. Hibler and Gupta (2010),Engineering Mechanics (Statics, Dynamics) by Pearson Education
7. Reddy Vijaykumar K. and K. Suresh Kumar(2010), Singer's Engineering Mechanics
8. Bansal R.K.(2010), A Text Book of Engineering Mechanics, Laxmi Publications
9. Khurmi R.S. (2010), Engineering Mechanics, S. Chand & Co.
10. Tayal A.K. (2010), Engineering Mechanics, Umesh Publications

Upon successful completion of the course, student should be able to:

- Use scalar and vector analytical techniques for analysing forces in statically determinate structures
- Apply fundamental concepts of kinematics and kinetics of particles to the analysis of simple, practical problems
- Apply basic knowledge of maths and physics to solve real-world problems
- Understand measurement error, and propagation of error in processed data
- Understand basic kinematics concepts – displacement, velocity and acceleration (and their angular counterparts);
- Understand basic dynamics concepts – force, momentum, work and energy;
- Understand and be able to apply Newton's laws of motion;

- Understand and be able to apply other basic dynamics concepts - the Work-Energy principle, Impulse-Momentum principle and the coefficient of restitution;
- Extend all of concepts of linear kinetics to systems in general plane motion (applying Euler's Equation and considering energy of a system in general plane motion, and the work of couples and moments of forces)
- Learn to solve dynamics problems. Appraise given information and determine which concepts apply, and choose an appropriate solution strategy; and
- Attain an introduction to basic machine parts such as pulleys and mass-spring systems.

ESC209	Mechanical Engineering	2L:2T:0P	3 credits

Module 1:Basic Concepts- Basic concepts - concept of continuum, macroscopic approach, Thermodynamic systems - closed, open and isolated. Property, state, path and process, quasistatic process, work, modes of work. Zeroth law of thermodynamics, concept of temperature and heat. Concept of ideal and real gases.

Module 2: First Law of Thermodynamics- Concepts of Internal Energy, Specific Heat Capacities, Enthalpy. Energy Balance for Closed and Open Systems, Energy Balance for Steady-Flow Systems. Steady-Flow Engineering Devices. Energy Balance for Unsteady-Flow

Module 3: Second Law of Thermodynamics- Thermal energy reservoirs, heat engines energy conversion, Kelvin’s and Clausius statements of second law, the Carnot cycle, the Carnot Theorem, the thermodynamic temperature scale, the Carnot heat engine, efficiency, the Carnot refrigerator and heat pump, COP. Clausius inequality, concept of entropy, principle of increase of entropy – availability, the increase of entropy principle, perpetual-motion machines, reversible and irreversible processes, Entropy change of pure substances, isentropic processes, property diagrams involving entropy, entropy change of liquids and solids, the entropy change of ideal gases, reversible steady-flow work, minimizing the compressor work, isentropic efficiencies of steady-flow devices, and entropy balance. Energy - a measure of work potential, including work potential of energy, reversible work and irreversibility, second-law efficiency, exergy change of a system, energy transfer by heat, work, and mass, the decrease of exergy principle and exergy destruction, energy balance: closed systems and control volumes energy balance.

Module 4: Properties Of Pure Substance- Properties of pure substances. Thermodynamic properties of pure substances in solid, liquid and vapour phases. Phase rule, P-V, P-T, T-V, T-S, H-S diagrams, PVT surfaces. Thermodynamic properties of steam. Calculations of work done and heat transfer in non- flow and flow processes.

Module 5: Power Cycles- Vapour and combined power cycles, including the Carnot vapor cycle, Rankine cycle: the ideal cycle for vapor power, the ideal reheat and regenerative and the second-law analysis of vapour power cycles. Gas power cycles, including basic considerations in the analysis of power cycles, the Carnot cycle and its value in engineering, an overview of reciprocating engines, air standard assumptions,gasoline engine Otto cycle, diesel engine cycle, gas-turbine Brayton cycle, and the second-law analysis of gas power cycles.

Module 6: Ideal and Real Gases and Thermodynamic Relations- Gas mixtures – properties ideal and real gases. Equation of state, Avogadro's Law, Vander Waal's equation of state, Compressibility factor, compressibility chart. Dalton's law of partial pressure. Exact differentials, T-D relations, Maxwell's relations. Clausius Clapeyron equations, Joule – Thomson coefficient.

Module 7: Psychrometry and psychrometric charts, property calculations of air vapour mixtures. Psychrometric process – Sensible heat exchange processes. Latent heat exchange processes. Adiabatic mixing, evaporative cooling. Use of standard thermodynamic tables, Mollier diagram, Psychometric chart and Refrigerant property tables. Refrigeration cycles, including refrigerators and heat pumps, the ideal reversed Carnot vapour-compression refrigeration cycle, actual vapor-compression refrigeration cycles, heat pump systems, gas refrigeration cycles, and absorption refrigeration systems.

Text/Reference Books:

1. Nag.P.K., "Engineering Thermodynamics", Tata McGraw-Hill, New Delhi.
2. Cengel, Thermodynamics – An Engineering Approach *Tata McGraw Hill, New* Delhi.
3. Sonntag, R. E., Borgnakke, C., & Wylen, G. J. V. Fundamentals of thermodynamics: Wiley.
4. Moran, M. J., Shapiro, H. N., Boettner, D. D., & Bailey, M. Fundamentals of Engineering
1. Thermodynamics: John Wiley & Sons.
5. Jones, J. B., & Dugan, R. E. Engineering thermodynamics: Prentice Hall.
6. Potter, M. C., & Somerton, C. W. Schaum's Outline of Thermodynamics for Engineers, McGraw-Hill.

Upon successful completion of the course, student will have:

- Ability to apply mathematics, science, and engineering
- Ability to design and conduct experiments, as well as to analyze and interpret data
- Ability to identify, formulate, and solve engineering problems
- Ability to apply modern engineering tools, techniques and resources to solve complex mechanical engineering activities with an understanding of the limitations.
- Ability to comprehend the thermodynamics and their corresponding processes that influence the behaviour and response of structural components
- Ability to apply principles of engineering, basic science, and mathematics (including multivariate calculus and differential equations) and thermodynamics to model, analyze, design, and realize physical systems, components, or processes

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ESC212	Energy Science & Engineering	1L:1T:0P	2 credits

The objective of this Course is to provide *an introduction to energy systems and renewable energy resources, with a scientific examination of the energy field and an emphasis on alternative energy sources and their technology and application. The class will explore society's present needs and future energy demands, examine conventional energy sources and systems, including fossil fuels and nuclear energy, and then focus on alternatives, renewable energy sources such as solar, biomass (conversions), wind power, waves and tidal, geothermal, ocean thermal, hydro and nuclear. Energy conservation methods will be emphasized* from Civil Engineering perspective. The knowledge acquired lays a good foundation for design of various civil engineering systems/ projects dealing with these energy generation paradigms in an efficient manner.

Proposed Syllabus
Module 1*: Introduction to Energy Science:* Scientific principles and historical interpretation to *place ener*gy use in the context of pressing societal, environmental and climate issues; Introduction to energy systems and resources; Introduction to Energy, sustainability & the environment

Module 2: *Energy Sources:* Overview of energy systems, sources, transformations, efficiency, and storage. Fossil fuels (coal, oil, oil-bearing shale and sands, coal gasification) - past, present & future, Remedies & alternatives for fossil fuels - biomass, wind, solar, nuclear, wave, tidal and hydrogen; Sustainability and environmental trade-offs of different energy systems; possibilities for energy storage or regeneration (Ex. Pumped storage hydro power projects, superconductor-based energy storages, high efficiency batteries)

Module 3:*Energy & Environment:* Energy efficiency and conservation; introduction to clean energy technologies and its importance in sustainable development; Carbon footprint, energy consumption and sustainability; introduction to the economics of energy; How the economic system determines production and consumption; linkages between economic and environmental outcomes; How future energy use can be influenced by economic, environmental, trade, and research policy

Module 4: *Civil Engineering Projects connected with the Energy Sources:* Coal mining technologies, Oil exploration offshore platforms, Underground and under-sea oil pipelines, solar chimney project, wave energy caissons, coastal installations for tidal power, wind mill towers; hydro power stations above-ground and underground along with associated dams, tunnels, penstocks, etc.; Nuclear reactor containment buildings and associated buildings, design and construction constraints and testing procedures for reactor containment buildings; Spent Nuclear fuel storage and disposal systems

Module 5: *Engineering for Energy conservation:* Concept of Green Building and Green Architecture;Green building concepts (Green building encompasses everything from the choice of building materials to where a building is located, how it is designed and operated); *LEED ratings;* Identification of energy related enterprises that represent the breath of the industry and prioritizing these as candidates; Embodied energy analysis and use as a tool for measuring sustainability. Energy Audit of Facilities and optimization of energy consumption

S.	Module	No of	Tutorial- to be derived for each module; typical

No		Lectures	examples given below.
1	Introduction to Energy Science	3	Compile a World map showing Energy Reserves by source, Total Energy consumption, Per capita energy consumption and Carbon Footprint
2	Energy Sources	4	Compile a Word Map showing Alternative Energy source usage; Compile a Process diagram for a Pumped Storage project; Collect details of a typical North Sea oil platform. Compile a map of India showing exiting potential and utilized potential for hydro power. List the pros and cons for Thermal, hydro, nuclear and solar power projects.
3	Energy & Environment	5	Study the functioning of an Electro Static Precipitator in a thermal power plant; study the uses of coarse and fine Fly Ash from thermal power plants. Compile the safety provisions in design and construction of a reactor containment building
4	Civil Engg projects connected with Energy Sources	10	Compile a process diagram for a typical underground hydro power project; Collect details of a model solar chimney project; collect details of a wave energy project at Vizhinjam; Collect details of the Kalpasar (Tidal energy) project
5	Engineering for Energy Conservation	8	Draw a typical geometrical orientation of a house in your area to avoid sun's radiation in the bed room in the evening; Identify typical examples of Indian buildings having various LEED ratings; List various building materials with their embodied energy content. Do an Energy Audit of your Departmental Building in the college
	TOTAL	**30**	**30**

Text/Reference Books:

1. Boyle, Godfrey (2004), Renewable Energy (2nd edition). Oxford University Press
2. Boyle, Godfrey, Bob Everett, and Janet Ramage (Eds.) (2004), Energy Systems and Sustainability: Power for a Sustainable Future. Oxford University Press
3. Schaeffer, John (2007), Real Goods Solar Living Sourcebook: The Complete Guide to Renewable Energy Technologies and Sustainable Living, Gaiam
4. Jean-Philippe; Zaccour, Georges (Eds.), (2005), Energy and Environment Set: Mathematics of Decision Making, Loulou, Richard; Waaub, XVIII,
5. Ristinen, Robert A. Kraushaar, Jack J. AKraushaar, Jack P. Ristinen, Robert A. (2006) Energy and the Environment, 2nd Edition, John Wiley
6. UNDP (2000), Energy and the Challenge of Sustainability, World Energy assessment
7. E H Thorndike (1976), Energy & Environment: A Primer for Scientists and Engineers, Addison-Wesley Publishing Company
8. Related papers published in international journals

Upon successful completion of the course, the students will be able to:

a) List and generally explain the main sources of energy and their primary applications nationally and internationally
b) Have basic understanding of the energy sources and scientific concepts/principles behind them

c) Understand effect of using these sources on the environment and climate
d) Describe the challenges and problems associated with the use of various energy sources, including fossil fuels, with regard to future supply and the impact on the environment.
e) List and describe the primary renewable energy resources and technologies.
f) To quantify energy demands and make comparisons among energy uses, resources, and technologies.
g) Collect and organize information on renewable energy technologies as a basis for further analysis and evaluation.
h) Understand the Engineering involved in projects utilising these sources

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3.4 PROFESSIONAL CORE COURSES/ FUNDAMENTAL ENGINEERING PRINCIPLES & TOOLS

PCC-CE201	**Instrumentation & Sensor Technologies for Civil Engineering Applications**	**1L:1T:2P**	**3 credits**

The objective of this Course is to understand instrumentation, sensor theory and technology, data acquisition, digital signal processing, damage detection algorithm, life time analysis and decision making. This course introduces theoretical and practical principles of design of sensor systems. Topics include: transducer characteristics for acoustic, current, temperature, pressure, electric, magnetic, gravity, salinity, concentration of contaminants, velocity, heat flow, and optical devices; limitations on these devices imposed by building/structure/pavement environments; signal conditioning and recording; noise, sensitivity, and sampling limitations; and standards. Lectures will cover the principles of state-of-the-art systems being used in physical infrastructure/bridges/buildings/pavements, etc. For lab work, the course will allow students to prepare, deploy and analyze observations from standard instruments. Laboratory experiments shall be used on application of concepts introduced in the lectures.

- Providing principle knowledge, practical training and measurement best practice for a range of temperature, pressure, electrical, velocity, acceleration and vibration systems

Proposed Syllabus

Module 1*: Fundamentals of Measurement, Sensing and Instrumentation covering* definition of measurement and instrumentation, physical variables, common types of sensors; Describe the function of these sensors; Use appropriate terminology to discuss sensor applications; and qualitatively interpret signals from a known sensor type, types of instrumentation, Sensor Specifics, Permanent installations, Temporary installations;

Module 2*: Sensor Installation and Operation covering to:* i) Predict the response of sensors to various inputs; ii) Construct a conceptual instrumentation and monitoring program; iii) Describe the order and methodology for sensor installation; and iv) Differentiate between types of sensors and their modes of operation and measurement and v) Approach to Planning Monitoring Programs, Define target, Sensor selection, Sensor siting, Sensor Installation & Configuration, Advanced topic, Sensor design, Measurement uncertainty

Module 3*: Data Analysis and Interpretation covering* a) Fundamental statistical concepts, b) Data reduction and interpretation, c) Piezometer, Inclinometer, Strain gauge, etc. d) Time domain signal processing, e) Discrete signals, Signals and noise and f) a few examples of statistical information to calculate are: Average value (mean), On average, how much each measurement deviates from the mean (standard deviation), Midpoint between the lowest and highest value of the set (median), Most frequently occurring value (mode), Span of values over which your data set occurs (range)

Module 4*: Frequency Domain Signal Processing and Analysis covering* Explain the need for frequency domain analysis and its principles; Draw conclusions about physical processes based on analysis of sensor data; Combine signals in a meaningful way to gain deeper insight into physical phenomena, Basic concepts in frequency domain signal processing and analysis, Fourier Transform, FFT (Fast Fourier Transform), Example problems: Noise reduction with filters, Leakage, Frequency resolution

Tutorials*from the above modules* demonstrating clearly the understanding and use for the sensors and instruments used for the problems posed and inferences drawn from the measurement and observations made along with evaluation report

Practicals:
Instrumentation of typical civil engineering members/structures/structural elements
Use of different sensors, strain gauges, inclinometers,
Performance characteristics
Errors during the measurement process
Calibration of measuring sensors and instruments
Measurement, noise and signal processing
Analog Signal processing
Digital Signal Processing
Demonstration & use of sensor technologies

Text/Reference Books:

1. Alan S Morris (2001), Measurement and Instrumentation Principles, 3rd/e, Butterworth Hienemann
2. David A. Bell (2007), Electronic Instrumentation and Measurements 2nd/e, Oxford Press
3. S. Tumanski (2006), Principle of Electrical Measurement, Taylor & Francis
4. Ilya Gertsbakh (2010), Measurement Theory for Engineers, Springer

What will I learn?

- Understand the principles of operation and characteristics of instrumentation and integrated sensor systems
- Understand right use of sensors and instruments for differing applications along with limitations
- Recognize and apply measurement best practice and identify ways to improve measurement and evaluation
- Troubleshoot and solve problems in instrumentation and measurement systems
- To instill and encourage a questioning culture

Outcomes:

- To analyze the errors during measurements
- To specify the requirements in the calibration of sensors and instruments
- To describe the noise added during measurements and transmission
- To describe the measurement of electrical variables
- To describe the requirements during the transmission of measured signals
- To construct Instrumentation/Computer Networks
- To suggest proper sensor technologies for specific applications
- To design and set up measurement systems and do the studies

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PCC-CE202	Engineering Geology	1L:0T:2P	2 credits

The objective of this Course is to focus on the core activities of engineering geologists – site characterization and geologic hazard identification and mitigation. Through lectures, labs, and case study examination student will learn to couple geologic expertise with the engineering properties of rock and unconsolidated materials in the characterization of geologic sites for civil work projects and the quantification of processes such as rock slides, soil-slope stability, settlement, and liquefaction.

Engineering geology is an applied geology discipline that involves the collection, analysis, and interpretation of geological data and information required for the safe development of civil works. Engineering geology also includes the assessment and mitigation of geologic hazards such earthquakes, landslides, flooding; the assessment of timber harvesting impacts; and groundwater remediation and resource evaluation. Engineering geologists are applied geoscientists with an awareness of engineering principles and practice—they are not engineers.

Proposed Syllabus:

Module 1: Introduction-Branches of geology useful to civil engineering, scope of geological studies in various civil engineering projects. Department dealing with this subject in India and their scope of work- GSI, Granite Dimension Stone Cell, NIRM. Mineralogy-Mineral, Origin and composition. Physical properties of minerals, susceptibility of minerals to alteration, basic of optical mineralogy, SEM, XRD., Rock forming minerals, megascopic identification of common primary & secondary minerals.

Module 2: Petrology-Rock forming processes. Specific gravity of rocks. Ternary diagram. Igneous petrology- Volcanic Phenomenon and different materials ejected by volcanoes. Types of volcanic eruption. Concept of Hot spring and Geysers. Characteristics of different types of magma. Division of rock on the basis of depth of formation, and their characteristics. Chemical and Mineralogical Composition. Texture and its types. Various forms of rocks. IUGS Classification of phaneritic and volcanic rock.. Field Classification chart. Structures. Classification of Igneous rocks on the basis of Chemical composition. Detailed study of Acidic Igneous rocks like Granite, Rhyolite or Tuff, Felsite, Pegmatite, Hornfels. Metamorphic Aureole, Kaolinization. Landform as Tors. Engineering aspect to granite. Basic Igneous rocks Like Gabbro, Dolerite, Basalt. Engineering aspect to Basalt. Sedimentary petrology- mode of formation, Mineralogical Composition. Texture and its types, Structures, Gradation of Clastic rocks. Classification of sedimentary rocks and their characteristics. Detailed study of Conglomerate, Breccia, Sandstone, Mudstone and Shale, Limestone Metamorphic petrology- Agents and types of metamorphism, metamorphic grades, Mineralogical composition, structures & textures in metamorphic rocks. Important Distinguishing features of rocks as Rock cleavage, Schistosity, Foliation. Classification. Detailed study of Gneiss, Schist, Slate with engineering consideration.

Module3: Physical Geology- Weathering. Erosion and Denudation. Factors affecting weathering and product of weathering. Engineering consideration. Superficial deposits and its geotechnical importance: Water fall and Gorges, River meandering, Alluvium, Glacial deposits, Laterite (engineering aspects), Desert Landform, Loess, Residual deposits of Clay with flints, Solifluction deposits, mudflows, Coastal deposits.

Module 4:Strength Behavior of Rocks- Stress and Strain in rocks. Concept of Rock Deformation & Tectonics. Dip and Strike. Outcrop and width of outcrop. Inliers and Outliers. Main types of discontinuities according to size. Fold- Types and nomenclature, Criteria for their recognition in field. Faults: Classification, recognition in field, effects on outcrops. Joints & Unconformity; Types, Stresses responsible, geotechnical importance. Importance of structural elements in engineering operations. Consequences of failure as land sliding, Earthquake and Subsidence. Strength of Igneous rock structures.

Module 5: Geological Hazards- Rock Instability and Slope movement: Concept of sliding blocks. Different controlling factors. Instability in vertical rock structures and measures to prevent collapse. . Types of landslide. Prevention by surface drainage, slope reinforcement by Rock bolting and Rock anchoring, retaining wall, Slope treatment. Case study on black clay. Ground water: Factors controlling water bearing capacity of rock. Pervious & impervious rocks and ground water. Lowering of water table and Subsidence. Earthquake: Magnitude and intensity of earthquake. Seismic sea waves. Revelation from Seismic Records of structure of earth. Case Study on Elevation and Subsidence in Himalayan region in India. Seismic Zone in India.

Module 6: Rock masses as construction material: Definition of Rock masses. Main features constituting rock mass. Main features that affects the quality of rock engineering and design. Basic element and structures of rock those are relevant in civil engineering areas. Main types of works connected to rocks and rock masses. Important variables influencing rock properties and behavior such as Fresh rock Influence from some minerals. Effect of alteration and weathering. Measurement of velocity of sound in rock. Classification of Rock material strength. Core logging .Rock Quality Designation. Rock mass description.

Module 7: Geology of dam and reservoir site- Required geological consideration for selecting dam and reservoir site. Failure of Reservoir. Favorable & unfavorable conditions in different types of rocks in presence of various structural features, precautions to be taken to counteract unsuitable conditions, significance of discontinuities on the dam site and treatment giving to such structures.

Module 8: Rock Mechanics- Sub surface 9nvestigations in rocks and engineering characteristics or rocks masses; Structural geology of rocks. Classification of rocks, Field & laboratory tests on rocks, Stress deformation of rocks, Failure theories and sheer strength of rocks, Bearing capacity of rocks.

Practicals:
1. Study of physical properties of minerals.
2. Study of different group of minerals.
3. Study of Crystal and Crystal system.
4. Identification of minerals: Silica group: Quartz, Amethyst, Opal; Feldspar group: Orthoclase, Plagioclase; Cryptocrystalline group: Jasper; Carbonate group: Calcite; Element group: Graphite; Pyroxene group: Talc; Mica group: Muscovite; Amphibole group: Asbestos, Olivine, Hornblende, Magnetite, Hematite, Corundum, Kyanite, Garnet, Galena, Gypsum.

5. Identification of rocks (Igneous Petrology): Acidic Igneous rock: Granite and its varieties, Syenite, Rhyolite, Pumice, Obsidian, Scoria, Pegmatite, Volcanic Tuff. Basic rock: Gabbro, Dolerite, Basalt and its varieties, Trachyte.
6. Identification of rocks (Sedimentary Petrology): Conglomerate, Breccia, Sandstone and its varieties , Laterite, Limestone and its varieties, Shales and its varieties.
7. Identification of rocks (Metamorphic Petrolody): Marble, slate, Gneiss and its varieties, Schist and its varieties. Quartzite, Phyllite.
8. Study of topographical features from Geological maps. Identification of symbols in maps.

Text/Reference Books:

1. Engineering and General Geology, Parbin Singh, 8th Edition (2010), S K Kataria & Sons.
2. Text Book of Engineering Geology, N. Chenna Kesavulu, 2nd Edition (2009), Macmillan Publishers India.
3. Geology for Geotechnical Engineers, J.C.Harvey, Cambridge University Press (1982).

What will I learn?

Students will be able to:

- Use suitable software to examine geology, soil, geologic hazard, and NEHRP data to characterize a geologic site.
- Calculate the bulk properties of rocks and unconsolidated sediments such as density, void ratio, water contents, and unit weights.
- Evaluate rock-mass quality and perform a kinematic analysis.
- Apply the factor of safety equation to solve planar rock slide and toppling problems.
- Perform a grain-size analysis, determine plastic and liquid limits, and classify soils using the Unified Soil Classification System.
- Calculate soil consolidation magnitudes and rates under induced stress conditions.
- Determine soil strength parameters from in situ tests.
- Apply the method of slices and factor of safety equation to solve rotational slide problems.

Outcomes:

Students will understand:

i) Site characterization and how to collect, analyze, and report geologic data using standards in engineering practice
ii) The fundamentals of the engineering properties of Earth materials and fluids.
iii) Rock mass characterization and the mechanics of planar rock slides and topples.
iv) Soil characterization and the Unified Soil Classification System.
v) The mechanics of soils and fluids and their influence on settlement, liquefaction, and soil slope stability.

PCC-CE203	**Disaster Preparedness & Planning Management**	**1L:1T:0P**	**2 credits**

The overall aim of this course is to provide broad understanding about the basic concepts of Disaster Management with preparedness as a Civil Engineer. Further, the course introduces the various natural hazards that can pose risk to property, lives, and livestock, etc. and

understanding of the social responsibility as an engineer towards preparedness as well as mitigating the damages.
The objectives of the course are i) To Understand basic concepts in Disaster Management ii) To Understand Definitions and Terminologies used in Disaster Management iii) To Understand Types and Categories of Disasters iv). To Understand the Challenges posed by Disasters vi) To understand Impacts of Disasters Key Skills

Proposed Syllabus
Module 1: Introduction - Concepts and definitions: disaster, hazard, vulnerability, risks-severity, frequency and details, capacity, impact, prevention, mitigation).

Module 2:Disasters - Disasters classification; natural disasters (floods, draught, cyclones, volcanoes, earthquakes, tsunami, landslides, coastal erosion, soil erosion, forest fires etc.); manmade disasters (industrial pollution, artificial flooding in urban areas, nuclear radiation, chemical spills, transportation accidents, terrorist strikes, etc.); hazard and vulnerability profile of India, mountain and coastal areas, ecological fragility.

Module 3:Disaster Impacts - Disaster impacts (environmental, physical, social, ecological, economic, political, etc.); health, psycho-social issues; demographic aspects (gender, age, special needs); hazard locations; global and national disaster trends; climate change and urban disasters.

Module 4: Disaster Risk Reduction (DRR) - Disaster management cycle – its phases; prevention, mitigation, preparedness, relief and recovery; structural and non-structural measures; risk analysis, vulnerability and capacity assessment; early warning systems, Post-disaster environmental response (water, sanitation, food safety, waste management, disease control, security, communications); Roles and responsibilities of government, community, local institutions, NGOs and other stakeholders; Policies and legislation for disaster risk reduction, DRR programmes in India and the activities of National Disaster Management Authority.

Module 5: Disasters, Environment and Development - Factors affecting vulnerability such as impact of developmental projects and environmental modifications (including of dams, land-use changes, urbanization etc.), sustainable and environmental friendly recovery; reconstruction and development methods.

Text/Reference Books:
1. http://ndma.gov.in/ (Home page of National Disaster Management Authority)
2. http://www.ndmindia.nic.in/ (National Disaster management in India, Ministry of Home Affairs).
3. Pradeep Sahni, 2004, Disaster Risk Reduction in South Asia, Prentice Hall.
4. Singh B.K., 2008, Handbook of Disaster Management: Techniques & Guidelines, Rajat Publication.
5. Ghosh G.K., 2006, Disaster Management, APH Publishing Corporation
6. Disaster Medical Systems Guidelines. Emergency Medical Services Authority, State of California, EMSA no.214, June 2003
7. Inter Agency Standing Committee (IASC) (Feb. 2007). IASC Guidelines on Mental Health and Psychosocial Support in Emergency Settings. Geneva: IASC

Outcomes:

The student will develop competencies in

- the application of Disaster Concepts to Management
- Analyzing Relationship between Development and Disasters.
- Ability to understand Categories of Disasters and
- realization of the responsibilities to society

PCC-CE204	Introduction to Fluid Mechanics	2L:0T:2P	3 credits

The objective of this course is to introduce the concepts of fluid mechanics useful in Civil Engineering applications. The course provides a first level exposure to the students to fluid statics, kinematics and dynamics. Measurement of pressure, computations of hydrostatic forces on structural components and the concepts of Buoyancy all find useful applications in many engineering problems. A training to analyse engineering problems involving fluids – such as those dealing with pipe flow, open channel flow, jets, turbines and pumps, dams and spillways, culverts, river and groundwater flow - with a mechanistic perspective is essential for the civil engineering students. The topics included in this course are aimed to prepare a student to build a good fundamental background useful in the application-intensive courses covering hydraulics, hydraulic machinery and hydrology in later semesters.

Module 1: Basic Concepts and Definitions – Distinction between a fluid and a solid; Density, Specific weight, Specific gravity, Kinematic and dynamic viscosity; variation of viscosity with temperature, Newton law of viscosity; vapour pressure, boiling point, cavitation; surface tension, capillarity, Bulk modulus of elasticity, compressibility.

Module 2: Fluid Statics - Fluid Pressure: Pressure at a point, Pascals law, pressure variation with temperature, density and altitude. Piezometer, U-Tube Manometer, Single Column Manometer, U-Tube Differential Manometer, Micromanometers. pressure gauges, Hydrostatic pressure and force: horizontal, vertical and inclined surfaces. Buoyancy and stability of floating bodies.

Module 3: Fluid Kinematics- Classification of fluid flow : steady and unsteady flow; uniform and non-uniform flow; laminar and turbulent flow; rotational and irrotational flow; compressible and incompressible flow; ideal and real fluid flow; one, two and three dimensional flows; Stream line, path line, streak line and stream tube; stream function, velocity potential function. One-, two- and three -dimensional continuity equations in Cartesian coordinates

Module 4: Fluid Dynamics- Surface and body forces; Equations of motion - Euler's equation; Bernoulli's equation – derivation; Energy Principle; Practical applications of Bernoulli's equation : venturimeter, orifice meter and pitot tube; Momentum principle; Forces exerted by fluid flow on pipe bend; Vortex Flow – Free and Forced; Dimensional Analysis and Dynamic Similitude - Definitions of Reynolds Number, Froude Number, Mach Number, Weber *Number and Euler Number; Buckingham's* π-Theorem.

Lab Experiments

1. Measurement of viscosity
2. Study of Pressure Measuring Devices
3. Stability of Floating Body
4. Hydrostatics Force on Flat Surfaces/Curved Surfaces
5. Verification of Bernoulli's Theorem
6. Venturimeter
7. Orifice meter
8. Impacts of jets
9. Flow Visualisation -Ideal Flow
10. Length of establishment of flow
11. Velocity distribution in pipes
12. Laminar Flow

Text/Reference Books:

1. Fluid Mechanics and Machinery, C.S.P.Ojha, R. Berndtsson and P. N. Chadramouli, Oxford University Press, 2010
2. Hydraulics and Fluid Mechanics, P M Modi and S M Seth, Standard Book House
3. Theory and Applications of Fluid Mechanics, K. Subramanya, Tata McGraw Hill
4. Fluid Mechanics with Engineering Applications, R.L. Daugherty, J.B. Franzini and E.J. Finnemore, International Student Edition, Mc Graw Hill.

At the end of the course, the student will be able to:

- Understand the broad principles of fluid statics, kinematics and dynamics
- Understand definitions of the basic terms used in fluid mechanics
- Understand classifications of fluid flow
- Be able to apply the continuity, momentum and energy principles
- Be able to apply dimensional analysis

PCC-CE205	Introduction to Solid Mechanics	1L:0T:2P	2 credits

The objective of this Course is to introduce to continuum mechanics and material modelling of engineering materials based on first energy principles: deformation and strain; momentum balance, stress and stress states; elasticity and elasticity bounds; plasticity and yield design. The overarching theme is a unified mechanistic language using thermodynamics, which allows understanding, modelling and design of a large range of engineering materials. The subject of mechanics of materials involves analytical methods for determining the strength, stiffness (deformation characteristics), and stability of the various members in a structural system. The behaviour of a member depends not only on the fundamental laws that govern the equilibrium of forces, but also on the mechanical characteristics of the material. These mechanical characteristics come from the laboratory, where materials are tested under accurately known forces and their behaviour is carefully observed and measured. For this reason, mechanics of materials is a blended science of experiment and Newtonian postulates of analytical mechanics.

Proposed Syllabus

Module1: *Simple Stresses and Strains-* Concept of stress and strain, St. Venant's principle, stress and strain diagram,Elasticity and plasticity – Types of stresses and strains, Hooke's law – stress – strain diagram for mild steel – Working stress – Factor of safety – Lateral strain, Poisson's ratio and volumetric strain – Elastic moduli and the relationship between them – Bars of varying section – composite bars – Temperature stresses. Strain Energy – Resilience – Gradual, sudden, impact and shock loadings – simple applications.

Module 2: Compound Stresses and Strains- Two dimensional system, stress at a point on a plane, principal stresses and principal planes, Mohr circle of stress, ellipse of stress and their applications. Two dimensional stress-strain system, principal strains and principal axis of strain, circle of strain and ellipse of strain. Relationship between elastic constants.

Module 3: Bending moment and Shear Force Diagrams- Bending moment (BM) and shear force (SF) diagrams.BM and SF diagrams for cantilevers simply supported and fixed beams with or without overhangs. Calculation of maximum BM and SF and the point of contra flexure under concentrated loads, uniformly distributed loads over the whole span or part of span, combination of concentrated loads (two or three) and uniformly distributed loads, uniformly varying loads, application of moments.

Module 4: *Flexural Stresses-Theory of simple bending* – Assumptions – Derivation of bending equation: M/I = f/y = E/R - Neutral axis – Determination of bending stresses – Section modulus of rectangular and circular sections (Solid and Hollow), I,T, Angle and Channel sections – Design of simple beam sections.

Module 5: *Shear Stresses- Derivation of formula* – Shear stress distribution across various beam sections like rectangular, circular, triangular, I, T angle sections.

Module 6: Slope and deflection- Relationship between moment, slope and deflection, Moment area method, Macaulay's method. Use of these methods to calculate slope and deflection for determinant beams.

Module 7: Torsion- Derivation of torsion equation and its assumptions. Applications of the equation of the hollow and solid circular shafts, torsional rigidity, Combined torsion and bending of circular shafts, principal stress and maximum shear stresses under combined loading of bending and torsion. Analysis of close-coiled-helical springs.

Module 8: Thin Cylinders and Spheres- Derivation of formulae and calculations of hoop stress, longitudinal stress in a cylinder, and sphere subjected to internal pressures.

List of Experiments:

- Tension test
- Bending tests on simply supported beam and Cantilever beam.
- Compression test on concrete
- Impact test
- Shear test
- Investigation of Hook's law that is the proportional relation between force and stretching in elastic deformation,

- Determination of torsion and deflection,
- Measurement of forces on supports in statically determinate beam,
- Determination of shear forces in beams,
- Determination of bending moments in beams,
- Measurement of deflections in statically determinate beam,
- Measurement of strain in a bar
- Bend test steel bar;
- Yield/tensile strength of steel bar;

Text/Reference Books:

1. Timoshenko, S. and Young, D. H., "Elements of Strength of Materials", DVNC, New York, USA.
2. Kazmi, S. M. A., "Solid Mechanics" TMH, Delhi, India.
3. Hibbeler, R. C. Mechanics of Materials. 6th ed. East Rutherford, NJ: Pearson Prentice Hall, 2004
4. Crandall, S. H., N. C. Dahl, and T. J. Lardner. An Introduction to the Mechanics of Solids. 2nd ed. New York, NY: McGraw Hill, 1979
5. Laboratory Manual of Testing Materials - William Kendrick Hall
6. Mechanics of Materials - Ferdinand P. Beer, E. Russel Jhonston Jr., John T. DEwolf – TMH 2002.
7. Strength of Materials by R. Subramanian, Oxford University Press, New Delhi.

Outcomes:

On completion of the course, the student will be able to:

- Describe the concepts and principles, understand the theory of elasticity including strain/displacement and Hooke's law relationships; and perform calculations, relative to the strength and stability of structures and mechanical components;
- Define the characteristics and calculate the magnitude of combined stresses in individual members and complete structures; analyze solid mechanics problems using classical methods and energy methods;
- Analyse various situations involving structural members subjected to combined stresses by application of Mohr's circle of stress; locate the shear center of thin wall beams;and
- Calculate the deflection at any point on a beam subjected to a combination of loads; solve for stresses and deflections of beams under unsymmetrical loading; apply various failure criteria for general stress states at points; solve torsion problems in bars and thin walled members;

PCC-CE206	Surveying and Geomatics	1L:1T:2P	3 credits

Course Objectives

With the successful completion of the course, the student should have the capability to:

a) describe the function of surveying in civil engineering construction,

b) Work with survey observations, and perform calculations,

c) Customary units of measure. Identify the sources of measurement errors and mistakes; understand the difference between accuracy and precision as it relates to distance, differential leveling, and angular measurements,

d) Be familiar with the principals of recording accurate, orderly, complete, and logical field notes from surveying operations, whether recorded manually or with automatic data collection methods,
e) Identify and calculate the errors in measurements and to develop corrected values for differential level circuits, horizontal distances and angles for open or closed-loop traverses,
f) Operate an automatic level to perform differential and profile leveling; properly record notes; mathematically reduce and check levelling measurements,
g) Effectively communicate with team members during field activities; identify appropriate safety procedures for personal protection; properly handle and use measurement instruments. Be able to identify hazardous environments and take measures to insure one's personal and team safety,
h) Measure horizontal, vertical, and zenith angles with a transit, theodolite, total station or survey grade GNSS instruments,
i) Calculate azimuths, latitudes and departures, error of closure; adjust latitudes and departures and determine coordinates for a closed traverse,
j) Perform traverse calculations; determine latitudes, departures, and coordinates of control points and balancing errors in a traverse. Use appropriate software for calculations and mapping,
k) Operate a total station to measure distance, angles, and to calculate differences in elevation. Reduce data for application in a geographic information system,
l) Work as a team member on a surveying party to achieve a common goal of accurate and timely project completion,
m) Calculate, design and layout horizontal and vertical curves, Understand, interpret, and prepare plan, profile, and cross-section drawings, Work with cross-sections and topographic maps to calculate areas, volumes, and earthwork quantities.

Proposed Syllabus:
Module 1: *Introduction to Surveying (8 hours):* Principles, Linear, angular and graphical methods, Survey stations, Survey lines- ranging, Bearing of survey lines, Levelling: Plane table surveying, Principles of levelling- booking and reducing levels; differential, reciprocal leveling, profile levelling and cross sectioning. Digital and Auto Level, Errors in levelling; contouring: Characteristics, methods, uses; areas and volumes.
Triangulation and Trilateration (6 Hours): Theodolite survey: Instruments, Measurement of horizontal and vertical angle; Horizontal and vertical control - methods -triangulation - network- Signals. Baseline - choices - instruments and accessories - extension of base lines - corrections - Satellite station - reduction to centre - Intervisibility of height and distances - Trigonometric leveling - Axis single corrections.

Module 2: Curves (6 hours) Elements of simple and compound curves – Method of setting out– Elements of Reverse curve - Transition curve – length of curve – Elements of transition curve - Vertical curves

Module 3: *Modern Field Survey Systems (8 Hours)*: Principle of Electronic Distance Measurement, Modulation, Types of EDM instruments, Distomat, Total Station – Parts of a Total Station – Accessories –Advantages and Applications, Field Procedure for total station survey, Errors in Total Station Survey; Global Positioning Systems- Segments, GPS measurements, errors and biases, Surveying with GPS, Co-ordinate transformation, accuracy considerations.

Module 4: *Photogrammetry Surveying (8 Hours)*: Introduction, Basic concepts, perspective geometry of aerial photograph, relief and tilt displacements, terrestrial photogrammetry, flight planning; Stereoscopy, ground control extension for photographic mapping- aerial triangulation, radial triangulation, methods; photographic mapping- mapping using paper prints, mapping using stereoplotting instruments, mosaics, map substitutes.

Module 5: *Remote Sensing (9 Hours)*: Introduction –Electromagnetic Spectrum, interaction of electromagnetic radiation with the atmosphere and earth surface, remote sensing data acquisition: platforms and sensors; visual image interpretation; digital image processing.

Text/Reference Books:

1 Madhu, N, Sathikumar, R and Satheesh Gobi, Advanced Surveying: Total Station, GIS and Remote Sensing, Pearson India, 2006.
2 Manoj, K. Arora and Badjatia, Geomatics Engineering, Nem Chand & Bros, 2011
3 Bhavikatti, S.S., Surveying and Levelling, Vol. I and II, I.K. International, 2010
4 Chandra, A.M., Higher Surveying, Third Edition, New Age International (P) Limited, 2002.
5 Anji Reddy, M., Remote sensing and Geographical information system, B.S. Publications, 2001.
6 Arora, K.R., Surveying, Vol-I, II and III, Standard Book House, 2015.

Outcomes:

The course will enable the students to:

- Apply the knowledge, techniques, skills, and applicable tools of the discipline to engineering and surveying activities
- Translate the knowledge gained for the implementation of Civil infrastructure facilities
- Relate the knowledge on Surveying to the new frontiers of science like Hydrographic surveying, Electronic Distance Measurement, Global Positioning System, Photogrammetry and Remote Sensing.

PCC-CE207	**Materials, Testing & Evaluation**	**1L:1T:2P**	**3 credits**

The objective of this Course is to deal with an experimental determination and evaluation of mechanical characteristics and advanced behavior of metallic and non-metallic structural materials. The course deals with explanation of deformation and fracture behavior of structural materials. The main goal of this course is to provide students with all information concerning principle, way of measurement, as well as practical application of mechanical characteristics.

- Make measurements of behavior of various materials used in Civil Engineering.
- Provide physical observations to complement concepts learnt
- Introduce experimental procedures and common measurement instruments, equipment, devices.

- Exposure to a variety of established material testing procedures and techniques
- Different methods of evaluation and inferences drawn from observations

The course reviews also the current testing technology and examines force applications systems, force measurement, strain measurement, important instrument considerations, equipment for environmental testing, and computers applications for materials testing provide an introductory treatment of *basic skills in material engineering towards (i) selecting material for the design, and (ii) evaluating the mechanical and structural properties of material, as well as the knowledge necessary for a civil engineer.* The knowledge acquired lays a good foundation for analysis and design of various civil engineering structures/systems in a reliable manner.

What will I learn?

- Different materials used in civil engineering applications
- Planning an experimental program, selecting the test configuration, selecting the test specimens and collecting raw data
- Documenting the experimental program including the test procedures, collected data, method of interpretation and final results
- Operating the laboratory equipment including the electronic instrumentation, the test apparatus and the data collection system
- Measuring physical properties of common structural and geotechnical construction materials
- Interpreting the laboratory data including conversion of the measurements into engineering values and derivation of material properties (strength and stiffness) from the engineering values
- Observing various modes of failure in compression, tension, and shear
- Observing various types of material behavior under similar loading conditions

Proposed Syllabus

Module 1: *Introduction to Engineering Materials covering,* Cements, M-Sand, Concrete (plain, reinforced and steel fibre/ glass fibre-reinforced, light-weight concrete, High Performance Concrete, Polymer Concrete) Ceramics, and Refractories, Bitumen and asphaltic materials, Timbers, Glass and Plastics, Structural Steel and other Metals, Paints and Varnishes, Acoustical material and geo-textiles, rubber and asbestos, laminates and adhesives, Graphene, Carbon composites and other engineering materials including properties and uses of these

Module 2: *Introduction to Material Testing covering,* What is the “Material Engineering”?; Mechanical behavior and mechanical characteristics; Elasticity – principle and characteristics; Plastic deformation of metals; Tensile test – standards for different material (brittle, quasi-brittle, elastic and so on) True stress – strain interpretation of tensile test; hardness tests; Bending and torsion test; strength of ceramic; Internal friction, creep – fundaments and characteristics; Brittle fracture of steel – temperature transition approach; Background of fracture mechanics; Discussion of fracture toughness testing – different materials; concept of fatigue of materials; Structural integrity assessment procedure and fracture mechanics

Module 3: *Standard Testing & Evaluation Procedures covering,* Laboratory for mechanical testing; Discussion about mechanical testing; Naming systems for various irons, steels and nonferrous metals; Discussion about elastic deformation; Plastic deformation; Impact test and transition temperatures; Fracture mechanics – background; Fracture toughness – different materials; Fatigue of material; Creep.

Tutorials *from the above modules covering*, understanding i) Tests & testing of bricks, ii) Tests & testing of sand, iii) Tests & testing of concrete, iv) Tests & testing of soils, v) Tests & testing of bitumen & bituminous mixes, vi) Tests & testing of polymers and polymer based materials, vii) Tests & testing of metals & viii) Tests & testing of other special materials, composites and cementitious materials. Explanation of mechanical behavior of these materials.

Practicals:

- Gradation of coarse and fine aggregates
- Different corresponding tests and need/application of these tests in design and quality control
- Tensile Strength of materials & concrete composites
- Compressive strength test on aggregates
- Tension I - Elastic Behaviour of metals & materials
- Tension II - Failure of Common Materials
- Direct Shear - Frictional Behaviour
- Concrete I - Early Age Properties
- Concrete II - Compression and Indirect Tension
- Compression – Directionality
- Soil Classification
- Consolidation and Strength Tests
- Tension III - Heat Treatment
- Torsion test
- Hardness tests (Brinnel's and Rockwell)
- Tests on closely coiled and open coiled springs
- Theories of Failure and Corroboration with Experiments
- Tests on unmodified bitumen and modified binders with polymers
- Bituminous Mix Design and Tests on bituminous mixes - Marshall method
- Concrete Mix Design as per BIS

Text/Reference Books:

1. Chudley, R., Greeno (2006), 'Building Construction Handbook' (6th ed.),R. Butterworth-Heinemann
2. Khanna, S.K., Justo, C.E.G and Veeraragavan, A, ' Highway Materials and Pavement Testing', Nem Chand& Bros, Fifth Edition
3. Various related updated & recent standards of BIS, IRC, ASTM, RILEM, AASHTO, etc. corresponding to materialsused for Civil Engineering applications
4. Kyriakos Komvopoulos (2011), Mechanical Testing of Engineering Materials, Cognella
5. E.N. Dowling (1993), Mechanical Behaviour of Materials,Prentice Hall International Edition
6. American Society for Testing and Materials (ASTM), *Annual Book of ASTM Standards* (post 2000)
7. Related papers published in international journals

Measurable Outcomes:

One should be able to:

- Calibrate electronic sensors
- Operate a data acquisition system
- Operate various types of testing machines
- Configure a testing machine to measure tension or compression behavior
- Compute engineering values (e.g. stress or strain) from laboratory measures
- Analyze a stress versus strain curve for modulus, yield strength and other related attributes
- Identify modes of failure
- Write a technical laboratory report

PCC-CE301	Mechanics of Materials	3L:0T:0P	3 credits

The objective of this Course is to introduce to continuum mechanics and material modeling of engineering materials based on first energy principles: deformation and strain; momentum balance, stress and stress states; elasticity and elasticity bounds; plasticity and yield design. The overarching theme is a unified mechanistic language using thermodynamics, which allows understanding, modelling and design of a large range of engineering materials. The subject of mechanics of materials involves analytical methods for determining the strength, stiffness (deformation characteristics), and stability of the various members in a structural system. The behavior of a member depends not only on the fundamental laws that govern the equilibrium of forces, but also on the mechanical characteristics of the material. These mechanical characteristics come from the laboratory, where materials are tested under accurately known forces and their behavior is carefully observed and measured (learnt in the previous course on Materials, Testing & Evaluation). For this reason, mechanics of materials is a blended science of experiment and Newtonian postulates of analytical mechanics.

What will I learn?

- Understand the deformation and strains under different load action and response in terms of forces and moments
- Understand the behaviour under different loading actions
- Application of engineering principles to calculate the reactions, forces and moments
- Understand the energy methods used to derive the equations to solve engineering problems
- Make use of the capabilities to determine the forces and moments for design

Proposed Syllabus

Module 1: *Deformation and Strain covering* description of finite deformation, Infinitesimal deformation; Analysis of statically determinate trusses; Stability of dams, retaining walls and chimneys; Stress analysis of thin, thick and compound cylinder;

Module 2:*Generalized state of stress and strain:* Stress and strain tensor, Yield criteria and theories of failure; Tresca, Von-Mises, Hill criteria, Heigh-Westerguard’s stress space.

Module 3:*Momentum Balance and Stresses covering* Forces and Moments Transmitted by Slender Members, Shear Force and Bending Moment Diagrams, Momentum Balance, Stress States / Failure Criterion

Module 4:*Mechanics of Deformable Bodies covering* Force-deformation Relationships and Static Indeterminacy, Uniaxial Loading and Material Properties, Trusses and Their Deformations, Statically Determinate and Indeterminate Trusses,

Module 5:*Force-Stress-Equilibrium covering* Multiaxial Stress and Strain

Module 6: *Displacement – Strain covering* Multiaxial Strain and Multiaxial Stress-strain Relationships

Module 7: *Elasticity and Elasticity Bounds covering*Stress-strain-temperature Relationships and Thin-walled Pressure Vessels,Stress and strain Transformations and Principal Stress, Failure of Materials,

Module 8:*Bending: Stress and Strains; Deflections and Torsion covering* Pure Bending, Moment-curvature Relationship, Beam Deflection, Symmetry, Superposition, and Statically Indeterminate Beams, Shear and Torsion, Torsion and Twisting, Thermoelasticity, Energy methods, Variational Methods; Strain energy, elastic, complementary and total strain energy, Strain energy of axially loaded bar, Beam in bending, shear and torsion; General energy theorems, Castigliano's theorem, Maxwell Bettie's reciprocal theorem; Virtual work and unit load method for deflection, Application to problems of beams and frames.

Module 9:*Structural stability;* Stability of columns, Euler's formula, end conditions and effective length factor, Columns with eccentric and lateral load; Plasticity and Yield Design covering 1D-Plasticity – An Energy Approach, Plasticity Models, Limit Analysis and Yield Design

Text/Reference Books:

1. Norris, C.H. and Wilber, J. B. and Utku, S. "Elementary Structural Analysis" Mc Graw Hill, Tokyo, Japan.
2. Timoshenko, S. and Young, D. H., "Elements of Strength of Materials", DVNC, New York, USA.
3. Kazmi, S. M. A., 'Solid Mechanics" TMH, Delhi, India.
4. Hibbeler, R. C. Mechanics of Materials. 6th ed. East Rutherford, NJ: Pearson Prentice Hall, 2004
5. Crandall, S. H., N. C. Dahl, and T. J. Lardner. An Introduction to the Mechanics of Solids. 2nd ed. New York, NY: McGraw Hill, 1979
6. Gere, J. M., and S. P. Timoshenko. *Mechanics of Materials.* 5th ed. Boston: PWS Kent Publishing, 1970.
7. Ashby, M. F., and D. R. H. Jones. *Engineering Materials, An Introduction to their Properties and Applications.* 2nd ed. Butterworth Heinemann.
8. Collins, J. A. *Failure of Materials in Mechanical Design.* 2nd ed. John Wiley & Sons, 1993.
9. Courtney, T. H. *Mechanical Behavior of Materials.* McGraw-Hill, 1990.

10. Hertzberg, R. W. *Deformation and Fracture Mechanics of Engineering Materials.* 4th ed. John Wiley & Sons, 1996.
11. Nash, W. A. *Strength of Materials.* 3d ed. Schaum's Outline Series, McGraw-Hill, 1994.

Outcomes:
At the end of the course, the student will have

- an ability to apply knowledge of mathematics, science, and engineering
- an ability to design a system, component, or process to meet desired needs
- an ability to identify, formulate, and solve engineering problems
- the broad education necessary to understand the impact of engineering solutions in a global and societal context
- an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
- an ability to apply principles of engineering, basic science, and math to model, analyze, design and realize physical systems, components or processes

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PCC-CE302	**Hydraulic Engineering**	**2L:0T:2P**	**3 credits**

Objectives:
To introduce the students to various hydraulic engineering problems like open channel flows and hydraulic machines. At the completion of the course, the student should be able to relate the theory and practice of problems in hydraulic engineering

Module 1: Laminar Flow- Laminar flow through: circular pipes, annulus and parallel plates. Stoke's law, Measurement of viscosity.

Module 2: Turbulent Flow- Reynolds experiment, Transition from laminar to turbulent flow. Definition of turbulence, scale and intensity, Causes of turbulence, instability, mechanism of turbulence and effect of turbulent flow in pipes. Reynolds stresses, semi-empirical theories of turbulence, Prandtl's mixing length theory, universal velocity distribution equation. Resistance to flow of fluid in smooth and rough pipes, Moody's diagram.

Module 3:Boundary Layer Analysis-Assumption and concept of boundary layer theory. Boundary-layer thickness, displacement, momentum & energy thickness, laminar and Turbulent boundary layers on a flat plate; Laminar sub-layer, smooth and rough boundaries. Local and average friction coefficients. Separation and Control.

Module 4: Dimensional Analysis and Hydraulic Similitude: Dimensional homogeneity, Rayleigh method, Buckingham's Pi method and other methods. Dimensionless groups. Similitude, Model studies, Types of models. Application of dimensional analysis and model studies to fluid flow problem.

Module 5: Introduction to Open Channel Flow-Comparison between open channel flow and pipe flow, geometrical parameters of a channel, classification of open channels, classification of open channel flow, Velocity Distribution of channel section.

Module 6: Uniform Flow-Continuity Equation, Energy Equation and Momentum Equation, Characteristics of uniform flow, Chezy’s formula, Manning’s formula. Factors affecting Manning’s Roughness Coefficient “n□.*Most economical section of ch*annel. Computation of Uniform flow, Normal depth.

Module 7 : Non-Uniform Flow- Specific energy, Specific energy curve, critical flow, discharge curve Specific force Specific depth, and Critical depth. Channel Transitions. Measurement of Discharge and Velocity – Venturi Flume, Standing Wave Flume, Parshall Flume, Broad Crested Weir. Measurement of Velocity- Current meter, Floats, Hot-wire anemometer. Gradually Varied Flow-Dynamic Equation of Gradually Varied Flow, Classification of channel bottom slopes, Classification of surface profile, Characteristics of surface profile. Computation of water surface profile by graphical, numerical and analytical approaches. Direct Step method, Graphical Integration method and Direct integration method.

Module 8: Hydraulic Jump- Theory of hydraulic jump, Elements and characteristics of hydraulic jump in a rectangular Channel, length and height of jump, location of jump, Types,applications and location of hydraulic jump. Energy dissipation and other uses, surge as a moving hydraulic jump. Positive and negative surges. Dynamics of Fluid Flow- Momentum principle, applications: Force on plates, pipe bends, moments of momentum equation,

Module 9: Flow through Pipes: Loss of head through pipes, Darcy-Wiesbatch equation, minor losses, total energy equation, hydraulic gradient line, Pipes in series, equivalent pipes, pipes in parallel, flow through laterals, flows in dead end pipes, siphon, power transmission through pipes, nozzles. Analysis of pipe networks: Hardy Cross method, water hammer in pipes and control measures, branching of pipes, three reservoir problem.

Module 10: Computational Fluid Dynamics: Basic equations of fluid dynamics, Grid generation, Introduction to in viscid incompressible flow, Boundary layer flow as applicable to C.F.D. Hydro informatics: Concept of hydro informatics –scope of internet and web based modeling in water resources engineering.

Practical Work:
1. Flow Visualization
2. Studies in Wind Tunnel
3. Boundary Layer
4. Flow around an Aerofoil / circular cylinder
5. Uniform Flow
6. Velocity Distribution in Open channel flow
7. Venturi Flume
8. Standing Wave Flume
9. Gradually Varied Flow

10. Hydraulic Jump
11. Flow under Sluice Gate
12. Flow through pipes
13. Turbulent flow through pipes
14. Flow visualization
15. Laminar flow through pipes
16. Major losses / Minor losses in pipe

Text/Reference Books:

1. Hydraulics and Fluid Mechanics, P.M. Modi and S.M. Seth, Standard Book House
2. Theory and Applications of Fluid Mechanics, K. Subramanya, Tata McGraw Hill.
3. Open channel Flow, K. Subramanya, Tata McGraw Hill.
4. Open Channel Hydraulics, Ven Te Chow, Tata McGraw Hill.
5. Burnside, C.D., "*Electromagnetic Distance Measurement*," Beekman Publishers, 1971.

Outcomes:

- The students will be able to apply their knowledge of fluid mechanics in addressing problems in open channels.
- They will possess the skills to solve problems in uniform, gradually and rapidly varied flows in steady state conditions.
- They will have knowledge in hydraulic machineries (pumps and turbines).

PCC-CE303	Structural Engineering	2L:1T:0P	3 credits

Objectives:

This course aims at providing students with a solid background on principles of structural engineering design. Students will be exposed to the theories and concepts of both concrete and steel design and analysis both at the element and system levels. Hands-on design experience and skills will be gained and learned through problem sets and a comprehensive design project. An understanding of real-world open-ended design issues will be developed. Weekly recitations and project discussions will be held besides lectures.

Module 1: Introduction- concepts of energy principles, safety, sustainable development in performance; what makes a structure; principles of stability, equilibrium; what is a structural engineer, role of engineer, architect, user, builder; what are the functions' what do the engineers design, first principles of process of design

Module 2: Planning and Design Process; Materials, Loads, and Design Safety; Behaviour and Properties of Concrete and Steel; Wind and Earthquake Loads

Module 3: *Materials and Structural Design Criteria:* Introduction to the analysis and design of structural systems. Analyses of determinate and indeterminate trusses, beams, and frames, and design philosophies for structural engineering. Laboratory experiments dealing with the analysis of determinate and indeterminate structures;

Module 4:*Design of Structural Elements;* Concrete Elements, Steel Elements, Structural Joints; Theories and concepts of both concrete and steel design and analysis both at the element and system levels. Approximate Analysis Methods as a Basis for Design; Design of

Reinforced Concrete Beams for Flexure; Design of Reinforced Concrete Beams for Shear; Bond, Anchorage, and Serviceability; Reinforced Concrete Columns; Reinforced Concrete Slabs; Introduction to Steel Design; Tension Members and Connections; Bending Members; Structural Systems

Module 5: *System Design Concepts;* Special Topics that may be Covered as Part of the Design Project Discussions; Cable Structures; Prestressed Concrete Bridges; Constructability and Structural Control; Fire Protection

Text/Reference Books:

1. Nilson, A. H. *Design of Concrete Structures.* 13th edition. McGraw Hill, 2004
2. McCormac, J.C., Nelson, J.K. Jr., *Structural Steel Design*. 3rd edition. Prentice Hall, N.J., 2003.
3. Galambos, T.V., Lin, F.J., Johnston, B.G., *Basic Steel Design with LRFD*, Prentice Hall, 1996
4. Segui, W. T., *LRFD Steel Design*, 2nd Ed., PWS Publishing, Boston.
5. Salmon, C.G. and Johnson, J.E., *Steel Structures: Design and Behavior,* 3rd Edition, Harper & Row, Publishers, New York, 1990.
6. MacGregor, J. G., *Reinforced Concrete: Mechanics and Design*, 3rd Edition, Prentice Hall, New Jersey, 1997.
7. Nawy, E. G., *Reinforced Concrete: A Fundamental Approach*, 5th Edition, Prentice Hall, New Jersey.
8. Wang C-K. and Salmon, C. G., *Reinforced Concrete Design*, 6th Edition, Addison Wesley, New York.
9. Nawy, E. G. *Prestressed Concrete: A Fundamental Approach*, Prentice Hall, NJ, (2003).
10. Related Codes of Practice of BIS
11. Smith, J. C., *Structural Analysis*, Harpor and Row, Publishers, New York.
12. W. McGuire, R. H. Gallagher and R. D. Ziemian. “Matrix Structural Analysis", 2nd Edition, John Wiley and Sons, 2000.
13. NBC, *National Building Code*, BIS (2017).
14. ASCE, *Minimum Design Loads for Buildings and Other Structures, ASCE 7-02*, American Society of Civil Engineers, Virginia, 2002.

Outcomes:

- The students will be able to apply their knowledge of structural mechanics in addressing design problems of structural engineering
- They will possess the skills to solve problems dealing with different loads and concrete and steel
- They will have knowledge in structural engineering

PCC-CE304	**Geotechnical Engineering**	**2L:0T:2P**	**3 credits**

Module 1: *Introduction*–Types of soils, their formation and deposition, Definitions: soil mechanics, soil engineering, rock mechanics, geotechnical engineering. Scope of soil engineering. Comparison and difference between soil and rock. Basic Definitions and Relationships-Soil as three-phase system in terms of weight, volume, voids ratio, and

porosity. Definitions: moisture content, unit weights, degree of saturation, voids ratio, porosity, specific gravity, mass specific gravity, etc. Relationship between volume weight, voids ratio- moisture content, unit weight- percent air voids, saturation- moisture content, moisture content- specific gravity etc. Determination of various parameters such as: Moisture content by oven dry method, pycnometer, sand bath method, torsional balance method,nuclear method, alcohol method and sensors. Specific gravity by density bottle method, pycnometer method, measuring flask method. Unit weight by water displacement method, submerged weight method, core-cutter method, sand-replacement method.
On completion of this module, the students must be able to:

- Understand the different types of soil based on their formation mechanism;
- Understand the various phase diagrams and derive various phase relationships of the soil;
- Perform various laboratory experiments to determine moisture content, specific gravity;
- Perform field experiments to estimate the field density of the soil mass.

Module 2: *Plasticity Characteristics of Soil* - Introduction to definitions of: plasticity of soil, consistency limits-liquid limit, plastic limit, shrinkage limit, plasticity, liquidity and consistency indices, flow & toughness indices, definitions of activity and sensitivity. Determination of: liquid limit, plastic limit and shrinkage limit. Use of consistency limits. Classification of Soils-Introduction of soil classification: particle size classification, textural classification, unified soil classification system, Indian standard soil classification system. Identification: field identification of soils, general characteristics of soil in different groups.
On completion of this module, the students must be able to:

- Understand the behaviour of soils based on their moisture contents;
- Perform laboratory experiments to estimate various Atterberg limits and evaluate index properties of soils;
- Classify any soils based on their particle size distribution and index properties;

Module 3: *Permeability of Soil* - Darcy’s law, validity of Darcy’s law. Determination of coefficient of permeability: Laboratory method: constant-head method, falling-head method. Field method: pumping- in test, pumping- out test. Permeability aspects: permeability of stratified soils, factors affecting permeability of soil. Seepage Analysis- Introduction, stream and potential functions, characteristics of flow nets, graphical method to plot flow nets.
On completion of this module, the student must be able to:

- Determine the permeability of soils through various laboratory and field tests;
- Analytically calculate the effective permeability of anisotropic soil mass;
- Determine the seepage quantities and pore water pressures below the ground;
- Graphically plot the equipotential lines and flow lines in a seepage flow.

Module 4:*Effective Stress Principle* - Introduction, effective stress principle, nature of effective stress, effect of water table. Fluctuations of effective stress, effective stress in soils saturated by capillary action, seepage pressure, quick sand condition.
On completion of this module, the student must be able to:

- Understand the physical significance of effective stress and its relation with pore pressure;
- Plot various stress distribution diagrams along the depth of the soil mass;
- Understand the effect of capillary action and seepage flow direction on the effective stress at a point in the soil mass.

Module 5: *Compaction of Soil*-Introduction, theory of compaction, laboratory determination of optimum moisture content and maximum dry density. Compaction in field, compaction specifications and field control.

On completion of this module, the student must be able to:

- Perform laboratory test to determine the maximum dry density and optimum moisture content of the soil;
- Variation in compaction curve with compaction effort and soil type;
- Determine the compactive effort required to obtain necessary degree of compaction in-situ;
- Differentiate among various field methods of compaction and their usage based on the type of soil.

Module 6:*Stresses in soils* – Introduction, stresses due to point load, line load, strip load, uniformly loaded circular area, rectangular loaded area. Influence factors, Isobars, Boussinesq's equation, Newmark's Influence Chart. Contact pressure under rigid and flexible area, computation of displacements from elastic theory.

On completion of this module, the student must be able to:

- Analytically compute the vertical stress in a semi-infinite soil mass due to various loading conditions;
- Plot isobars due various loading conditions.

Module 7:*Consolidation of Soil* - Introduction, comparison between compaction and consolidation, initial, primary & secondary consolidation, spring analogy for primary consolidation, interpretation of consolidation test results, Terzaghi's theory of consolidation, final settlement of soil deposits, computation of consolidation settlement and secondary consolidation.

On completion of this module, the student must be able to:

- Understand the basic mechanism of consolidation of soil;
- Determine various consolidation parameters of soil through laboratory test;
- Evaluate ground settlements against time.

Module 8:*Shear Strength* - Mohr circle and its characteristics, principal planes, relation between major and minor principal stresses,Mohr-Coulomb theory, types of shear tests: direct shear test, merits of direct shear test, triaxial compression tests, test behaviour of UU, CU and CD tests, pore-pressure measurement, computation of effective shear strength parameters.unconfined compression test, vane shear test

On completion of this module, the student must be able to:

- Determine graphically and analytically the stress state in any plane of the soil mass;
- Perform various shear strength tests and appreciate the different field conditions which they simulate;
- Understand the significance of shear strength parameters in various geotechnical analyses;
- Evaluate the stiffness of soil using shear strength parameters

Module 9:*Stability of Slopes* - Introduction, types of slopes and their failure mechanisms, factor of safety, analysis of finite and infinite slopes, wedge failure Swedish circle method, friction circle method, stability numbers and charts.
On completion of this module, the student must be able to:

- Differentiate various modes of slope failure;
- Evaluate factor of safety of infinite slopes based on different ground conditions;
- Understand various methods for computation of factor of safety for finite slopes.

Module 10:*Soil Exploration*- Introduction, methods of site exploration and soil investigation, methods of boring, soil samplers, sampling procedures, trail pits, borings, penetrometer tests, analysis of borehole logs, geophysical and advance soil exploration methods.

On completion of this module, the student must be able to:

- Specify a strategy for site investigation to identify the soil deposits and determine the depth and spatial extent within the ground;
- Understand various site investigation techniques and their in-situ applications;
- Prepare a soil investigation report based on borehole log data and various in-situ tests like SPT, CPT, etc.

Practical Work: List of tests on-
1. Field Density using Core Cutter method.
2. Field Density using Sand replacement method.
3. Natural moisture content using Oven Drying method.
4. Field identification of Fine Grained soils.
5. Specific gravity of Soils.
6. Grain size distribution by Sieve Analysis.
7. Grain size distribution by Hydrometer Analysis.
8. Consistency limits by Liquid limit
9. Consistency limits by Plastic limit
10. Consistency limits by Shrinkage limit.
11. Permeability test using Constant-head test method.
12. Permeability test using Falling-head method.
13. Compaction test: Standard Proctor test.
14. Compaction test: Modified Proctor test.
15. Relative density.
16. Consolidation Test.
17. Triaxial Test (UU)
18. Vane shear test
19. Direct Shear Test
20. Unconfined Compression Strength Test.

Text/Reference Books:

1. Soil Mechanics by Craig R.F., Chapman & Hall
2. Fundamentals of Soil Engineering by Taylor, John Wiley & Sons
3. An Introduction to Geotechnical Engineering, by Holtz R.D. and Kovacs, W.D., Prentice Hall, NJ
4. Principles of Geotechnical Engineering, by Braja M. Das, Cengage Learning
5. Principles of Foundation Engineering, by Braja M. Das, Cengage Learning

6. Essentials of Soil Mechanics and Foundations: Basic Geotechnics by David F. McCarthy
7. Soil Mechanics in Engineering Practice by Karl Terzaghi, Ralph B. Peck, and Gholamreza Mesri.
8. Geotechnical Engineering: Principles and Practices of Soil Mechanics and Foundation Engineering (Civil and Environmental Engineering) by V.N.S. Murthy

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PCC-CE305	Hydrology and Water Resources Engineering	2L:2T:0P	3 credits

Module 1: *Introduction* - hydrologic cycle, water-budget equation, history of hydrology, world
water balance, applications in engineering, sources of data.

Module 2: *Precipitation* - forms of precipitation, characteristics of precipitation in India, measurement of precipitation, rain gauge network, mean precipitation over an area, depth-area-duration relationships, maximum intensity/depth-duration-frequency relationship, Probable Maximum Precipitation (PMP), rainfall data in India.

Module 3:*Abstractions from precipitation* - evaporation process, evaporimeters, analytical methods of evaporation estimation, reservoir evaporation and methods for its reduction, evapotranspiration, measurement of evapotranspiration, evapotranspiration equations, potential evapotranspiration over India, actual evapotranspiration, interception, depression storage, infiltration, infiltration capacity, measurement of infiltration, modelling infiltration capacity, classification of infiltration capacities, infiltration indices.

Module 4:*Runoff* - runoff volume, SCS-CN method of estimating runoff volume, flow-duration curve, flow-mass curve, hydrograph, factors affecting runoff hydrograph, components of hydrograph, base flow separation, effective rainfall, unit hydrograph surface water resources of India, environmental flows.

Module 5: *Ground water and well hydrology* - forms of subsurface water, saturated formation, aquifer properties, geologic formations of aquifers, well hydraulics: steady state flow in wells, equilibrium equations for confined and unconfined aquifers, aquifer tests.

Module 6:*Water withdrawals and uses* – water for energy production, water for agriculture, water for hydroelectric generation; flood control. Analysis of surface water supply, Water requirement of crops-Crops and crop seasons in India, cropping pattern, duty and delta; Quality of irrigation water; Soil-water relationships, root zone soil water, infiltration, consumptive use, irrigation requirement, frequency of irrigation; Methods of applying water to the fields: surface, sub-surface, sprinkler and trickle / drip irrigation.

Module 7:*Distribution systems* - canal systems, alignment of canals, canal losses, estimation of design discharge. Design of channels- rigid boundary channels, alluvial channels, Kennedy's and Lacey's theory of regime channels. Canal outlets: non-modular, semi-modular and modular outlets. Water logging: causes, effects and remedial measures. Lining of canals, types of lining. Drainage of irrigated lands: necessity, methods.

Module 8: *Dams and spillways* - embankment dams: Classification, design considerations, estimation and control of seepage, slope protection. Gravity dams: forces on gravity dams, causes of failure, stress analysis, elementary and practical profile. Arch and buttress dams. Spillways: components of spillways, types of gates for spillway crests; Reservoirs- Types, capacity of reservoirs, yield of reservoir, reservoir regulation, sedimentation, economic height of dam, selection of suitable site.

Text/Reference Books:

1. K Subramanya, Engineering Hydrology, Mc-Graw Hill.
2. K N Muthreja, Applied Hydrology, Tata Mc-Graw Hill.
3. K Subramanya, Water Resources Engineering through Objective Questions, Tata Mc-Graw Hill.
4. G L Asawa, Irrigation Engineering, Wiley Eastern
5. L W Mays, Water Resources Engineering, Wiley.
6. J D Zimmerman, Irrigation, John Wiley & Sons
7. C S P Ojha, R Berndtsson and P Bhunya, Engineering Hydrology, Oxford.

Outcomes:

At the end of the course, students must be in a position to:

- Understand the interaction among various processes in the hydrologic cycle
- Apply the application of fluid mechanics and use of computers in solving a host of problems in hydraulic engineering
- Study types and classes of hydrologic simulation models and design procedures for safe and effective passage of flood flows for design of hydraulic structures
- Understand the basic aquifer parameters and estimate groundwater resources for different hydro-geological boundary conditions
- Understand application of systems concept, advanced optimization techniques to cover the socio-technical aspects in the field of water resources
- Apply the principles and applications of remote sensing, GPS and GIS in the context to hydrological extreme flood and drought events in water resources engineering

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PCC-CE306	Environmental Engineering	2L:2T:0P	3 credits

Module 1: *Water:* -Sources of Water and quality issues, water quality requirement for different beneficial uses, Water quality standards, water quality indices, water safety plans, Water Supply systems, Need for planned water supply schemes, Water demand industrial and agricultural water requirements, Components of water supply system; Transmission of water, Distribution system, Various valves used in W/S systems, service reservoirs and design.
Water Treatment: aeration, sedimentation, coagulation flocculation, filtration, disinfection, advanced treatments like adsorption, ion exchange, membrane processes

Module 2: *Sewage-* Domestic and Storm water, Quantity of Sewage, Sewage flow variations. Conveyance of sewage- Sewers, shapes design parameters, operation and maintenance of sewers, Sewage pumping; Sewerage, Sewer appurtenances, Design of sewerage systems. Small bore systems, Storm Water- Quantification and design of Storm water; Sewage and Sullage, Pollution due to improper disposal of sewage, National River cleaning plans, Wastewater treatment, aerobic and anaerobic treatment systems, suspended and attached growth systems, recycling of sewage – quality requirements for various purposes.

Module 3: *Air* - Composition and properties of air, Quantification of air pollutants, Monitoring of air pollutants, Air pollution- Occupational hazards, Urban air pollution automobile pollution, Chemistry of combustion, Automobile engines, quality of fuel, operating conditions and interrelationship. Air quality standards, Control measures for Air pollution, construction and limitations

Module 4: *Noise*- Basic concept, measurement and various control methods.

Module5:*Solid waste management*-Municipal solid waste, Composition and various chemical and physical parameters of MSW, MSW management: Collection, transport, treatment and disposal of MSW. Special MSW: waste from commercial establishments and other urban areas, solid waste from construction activities, biomedical wastes, Effects of solid waste on environment: effects on air, soil, water surface and ground health hazards. Disposal of solid waste-segregation, reduction at source, recovery and recycle. Disposal methods-Integrated solid waste management. Hazardous waste: Types and nature of hazardous waste as per the HW Schedules of regulating authorities.

Module 6: *Building Plumbing*-Introduction to various types of home plumbing systems for water supply and waste water disposal, high rise building plumbing, Pressure reducing valves, Break pressure tanks, Storage tanks, Building drainage for high rise buildings, various kinds of fixtures and fittings used.

Module 7: Government authorities and their roles in water supply, sewerage disposal. Solid waste management and monitoring/control of environmental pollution.

Practical Work: List of Experiments

1. Physical Characterization of water: Turbidity, Electrical Conductivity, pH
2. Analysis of solids content of water: Dissolved, Settleable, suspended, total, volatile, inorganic etc.
3. Alkalinity and acidity, Hardness: total hardness, calcium and magnesium hardness
4. Analysis of ions: copper, chloride and sulfate
5. Optimum coagulant dose
6. Chemical Oxygen Demand (COD)
7. Dissolved Oxygen (D.O) and Biochemical Oxygen Demand (BOD)
8. Break point Chlorination
9. Bacteriological quality measurement: MPN,
10. Ambient Air quality monitoring (TSP, RSPM, SOx, NOx)
11. Ambient noise measurement

Text/Reference Books:

1. Introduction to Environmental Engineering and Science by Gilbert Masters, Prentice Hall, New Jersey.
2. Introduction to Environmental Engineering by P. Aarne Vesilind, Susan M. Morgan, Thompson /Brooks/Cole; Second Edition 2008.
3. Peavy, H.s, Rowe, D.R, Tchobanoglous, G. *Environmental Engineering*, Mc-Graw - Hill International Editions, New York 1985.

4. MetCalf and Eddy. *Wastewater Engineering, Treatment, Disposal and Reuse*, Tata McGraw-Hill, New Delhi.
5. Manual on Water Supply and Treatment. Ministry of Urban Development, New Delhi.
6. Plumbing Engineering. Theory, Design and Practice, S.M. Patil, 1999
7. Integrated Solid Waste Management, Tchobanoglous, Theissen & Vigil. McGraw Hill Publication
8. Manual on Sewerage and Sewage Treatment Systems, Part A, B and C. Central Public Health and Environmental Engineering Organization, Ministry of Urban Development.

Outcomes:

After successfully studying this course, students will:

- Understand the impact of humans on environment and environment on humans
- Be able to identify and value the effect of the pollutants on the environment: atmosphere, water and soil.
- Be able to plan strategies to control, reduce and monitor pollution.
- Be able to select the most appropriate technique for the treatment of water, wastewater solid waste and contaminated air.
- Be conversant with basic environmental legislation.

PCC-CE307	Transportation Engineering	2L:0T:2P	3 credits

Module 1: Highway development and planning-Classification of roads, road development in India, Current road projects in India; highway alignment and project preparation.

Module 2: Geometric design of highways-: Introduction; highway cross section elements; sight distance, design of horizontal alignment; design of vertical alignment; design of intersections, problems

Module 3:Traffic engineering & control- Traffic Characteristics, traffic engineering studies, traffic flow and capacity, traffic regulation and control; design of road intersections; design of parking facilities; highway lighting; problems

Module 4:Pavement materials- Materials used in Highway Construction- Soils, Stone aggregates, bituminous binders, bituminous paving mixes; Portland cement and cement concrete: desirable properties, tests, requirements for different types of pavements. Problems

Module 5: Design of pavements- Introduction; flexible pavements, factors affecting design and performance; stresses in flexible pavements; design of flexible pavements as per IRC; rigid pavements- components and functions; factors affecting design and performance of CC pavements; stresses in rigid pavements; design of concrete pavements as per IRC; problems

Text/Reference Books:

1. Khanna, S.K., Justo, C.E.G and Veeraragavan, A, 'Highway Engineering', Revised 10th Edition, Nem Chand & Bros, 2017
2. Kadiyalai, L.R., ' Traffic Engineering and Transport Planning', Khanna Publishers.
3. Partha Chakraborty, ' Principles Of Transportation Engineering, PHI Learning,

4. Fred L. Mannering, Scott S. Washburn, Walter P. Kilareski,'Principles of Highway Engineering and Traffic Analysis', 4th Edition, John Wiley
5. Srinivasa Kumar, R, Textbook of Highway Engineering, Universities Press, 2011.
6. Paul H. Wright and Karen K. Dixon, Highway Engineering, 7th Edition, Wiley Student Edition, 2009.

On completion of the course, the students will be able to:

- carry out surveys involved in planning and highway alignment
- design the geometric elements of highways and expressways
- carry out traffic studies and implement traffic regulation and control measures and intersection design
- characterize pavement materials and
- design flexible and rigid pavements as per IRC

PCC-CE308	Construction Engineering & Management	2L:1T:0P	3 credits

Module 1: *Basics of* Construction- Unique features of construction, construction projects-types and features, phases of a project, agencies involved and their methods of execution;

Module 2: Construction project planning- Stages of project planning: pre-tender planning, pre-construction planning, detailed construction planning, role of client and contractor, level of detail. Process of development of plans and schedules, work break-down structure, activity lists, assessment of work content, concept of productivities, estimating durations, sequence of activities, activity utility data; Techniques of planning- Bar charts, Gantt Charts. Networks: basic terminology, types of precedence relationships, preparation of CPM networks: activity on link and activity on node representation, computation of float values, critical and semi critical paths, calendaring networks.PERT- Assumptions underlying PERT analysis, determining three time estimates, analysis, slack computations, calculation of probability of completion.

Module 3: Construction Methods basics: Types of foundations and construction methods; Basics of Formwork and Staging; Common building construction methods (conventional walls and slabs; conventional framed structure with blockwork walls; Modular construction methods for repetitive works; Precast concrete construction methods; Basics of Slip forming for tall structures; Basic construction methods for steel structures; Basics of construction methods for Bridges.

Module 4: Construction Equipment basics*:* Conventional construction methods Vs Mechanized methods and advantages of latter; Equipment for Earthmoving, Dewatering; Concrete mixing, transporting & placing; Cranes, Hoists and other equipment for lifting; Equipment for transportation of materials. Equipment Productivities

Module 5: Planning and organizing construction site and resources- Site: site layout including enabling structures, developing site organization, Documentation at site; Manpower: planning, organizing, staffing, motivation; Materials: concepts of planning, procurement and inventory control; Equipment: basic concepts of planning and organizing; Funds: cash flow, sources of funds; Histograms and S-Curves. Earned Value; Resource Scheduling- Bar chart, line of balance technique, resource constraints and conflicts; resource aggregation, allocation, smoothening and leveling. Common Good Practices in Construction

Module 6:*Project Monitoring & Control-* Supervision, record keeping, periodic progress reports, periodical progress meetings. Updating of plans: purpose, frequency and methods of updating. Common causes of time and cost overruns and corrective measures. Basics of Modern Project management systems such as Lean Construction; Use of Building Information Modelling (BIM) in project management; Quality control: concept of quality, quality of constructed structure, use of manuals and checklists for quality control, role of inspection, basics of statistical quality control. Safety, Health and Environment on project sites: accidents; their causes, effects and preventive measures, costs of accidents, occupational health problems in construction, organizing for safety and health.

Module 7:*Contracts Management basics:* Importance of contracts; Types of Contracts, parties to a contract; Common contract clauses (Notice to proceed, rights and duties of various parties, notices to be given, Contract Duration and Price. Performance parameters; Delays, penalties and liquidated damages; Force Majeure, Suspension and Termination. Changes & variations, Dispute Resolution methods.

Module 8:*Construction Costs: Make-up of construction costs;* Classification of costs, time-cost trade-off in construction projects, compression and decompression.

Text/Reference Books:

1. Varghese, P.C., "*Building Construction*", Prentice Hall India, 2007.
2. *National Building Code,* Bureau of Indian Standards, New Delhi, 2017.
3. Chudley, R., *Construction Technology*, ELBS Publishers, 2007.
4. Peurifoy, R.L. Construction Planning, Methods and Equipment, McGraw Hill, 2011
5. Nunnally, S.W. Construction Methods and Management, Prentice Hall, 2006
6. Jha, Kumar Neeraj., Construction Project management, Theory & Practice, Pearson Education India, 2015
7. Punmia, B.C., Khandelwal, K.K., Project Planning with PERT and CPM, Laxmi Publications, 2016.

S.No	Module (No of Lectures in brackets)	Tutorials
1	Basics of Construction (2)	
2	Construction Planning (6)	Develop a WBD structure for the construction of one storeyed building; Develop a bar chart for the construction of this building, including finishing activities, assuming reasonable activity durations.

3	Construction Methods basics (6)	Develop a CPM chart for a 5 span bridge on open foundations. Develop a comparative table for a 10-storeyed building constructed by at least three different methods, listing their pros and cons.
4	Construction Equipment Basics (3)	Develop a Gantt Chart for the construction of a two storeyed precast framed structure, including open foundations, along with list of equipment resources, assuming reasonable quantities and productivities. Develop a bar chart for concreting 1500 sq.m. of a 15cm. thick slab using various equipment for production to placing of concrete at 3m height above ground level; show all equipment resources required, along with a site layout.
5	Planning and Organizing Construction Site and Resources (4)	For the construction of a typical 3 storeyed, framed structure with 400 sq.m. area per floor develop the histograms for the various resources required, showing all intermediate calculations; also, draw S-curves for concrete placing and blockwork done over the period.
6	Project Monitoring and Control (4)	Write a 500-word note on the advantages of Lean Construction method over conventional project management systems. Write a 500-word note on the Safety and Health precautions you would take for a typical 3 storeyed building with 400 sq. m. plinth area.
7	Contract Management basics (3)	Assuming a 4 month delay in a construction contract of 24 months duration, form 3 groups for arguing the case for or against levying penalty on the contractor; Group A to formulate the contract conditions, Group B to act as Client and Group C to act as the Contractor. One person to act as Arbitrator/ Judge.
8	Construction Costs (2)	Refer to a Standard Schedule of Rates of any PWD (available on the Net), develop the approximate cost of a 3 storey, 400 sqm plinth area building.
	Total: 30 Lectures	15 Tutorials

On completion of the course, the students will have:

- An idea of how structures are built and projects are developed on the field
- An understanding of modern construction practices
- A good idea of basic construction dynamics- various stakeholders, project objectives, processes, resources required and project economics

- A basic ability to plan, control and monitor construction projects with respect to time and cost
- An idea of how to optimise construction projects based on costs
- An idea how construction projects are administered with respect to contract structures and issues.
- An ability to put forward ideas and understandings to others with effective communication processes

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PCC-CE309	Engineering Economics, Estimation & Costing	2L:1T:4P	5 credits

Module 1:Basic Principles and Methodology of Economics. Demand/Supply – elasticity – Government Policies and Application. Theory of the Firm and Market Structure. Basic Macro-economic Concepts (including GDP/GNP/NI/Disposable Income) and Identities for both closed and open economies. Aggregate demand and Supply (IS/LM). Price Indices (WPI/CPI), Interest rates, Direct and Indirect Taxes (3 lectures)

Module 2: Public Sector Economics –Welfare, Externalities, Labour Market. Components of Monetary and Financial System, Central Bank –Monetary Aggregates; Commercial Banks & their functions; Capital and Debt Markets. Monetary and Fiscal Policy Tools & their impact on the economy – Inflation and Phillips Curve. (2 lectures)

Module 3: Elements of Business/Managerial Economics and forms of organizations. Cost & Cost Control –Techniques, Types of Costs, Lifecycle costs, Budgets, Break even Analysis, Capital Budgeting, Application of Linear Programming. Investment Analysis – NPV, ROI, IRR, Payback Period, Depreciation, Time value of money (present and future worth of cash flows). Business Forecasting – Elementary techniques. Statements – Cash flow, Financial. Case Study Method. (3 lectures)

Module 4: Indian economy - Brief overview of post-independence period – plans. Post reform Growth, Structure of productive activity. Issues of Inclusion – Sectors, States/Regions, Groups of people (M/F), Urbanization. Employment–Informal, Organized, Unorganized, Public, Private. Challenges and Policy Debates in Monetary, Fiscal, Social, External sectors. (2 lectures)

Module 5:*Estimation /* Measurements for various items- Introduction to the process of Estimation; Use of relevant Indian Standard Specifications for the same, taking out quantities from the given requirements of the work, comparison of different alternatives, Bar bending schedules, Mass haul Diagrams, Estimating Earthwork and Foundations, Estimating Concrete and Masonry, Finishes, Interiors, MEP works; BIM and quantity take-offs; adding equipment costs; labour costs; rate analysis; Material survey-Thumb rules for computation of materials requirement for different materials for buildings, percentage breakup of the cost, cost sensitive index, market survey of basic materials. Use of Computers in quantity surveying (7 lectures)

Module 6: Specifications-Types, requirements and importance, detailed specifications for buildings, roads, minor bridges and industrial structures. (3 lectures)

Module 7: Rate analysis-Purpose, importance and necessity of the same, factors affecting, task work, daily output from different equipment/ productivity. (3 lectures)

Module 8: Tender- Preparation of tender documents, importance of inviting tenders, contract types, relative merits, prequalification. general and special conditions, termination of contracts, extra work and Changes, penalty and liquidated charges, Settlement of disputes, R.A. Bill & Final Bill, Payment of advance, insurance, claims, price variation, etc. Preparing Bids- Bid Price buildup: Material, Labour, Equipment costs, Risks, Direct & Indirect Overheads, Profits; Bid conditions, alternative specifications; Alternative Bids. Bid process management (6 lectures)

Module 9: Introduction to Acts pertaining to-Minimum wages, Workman's compensation, Contracts, Arbitration, Easement rights. (1 lecture)

Term Work Assignments may include:
1. Deriving an approximate estimate for a multistoried building by approximate methods.
2. Detailed estimate for the following with the required material survey for the same.
    a. Ground plus three storied RCC Framed structure building with blockwork walls
    b. bridge with minimum 2 spans
    c. factory building
    d. road work
    e. cross drainage work
    f. Ground plus three storied building with load-bearing walls
    g Cost of finishes, MEP works for (f) above
3. Preparation of valuation report in standard Government form.
4. Assignments on rate analysis, specifications and simple estimates.
5. Detailed estimate of minor structure.
6. Preparation of Bar bending schedule.

Text/Reference Books:

1. Mankiw Gregory N. (2002), *Principles of Economics,* Thompson Asia
2. V. Mote, S. Paul, G. Gupta(2004), *Managerial Economics,* Tata McGraw Hill
3. Misra, S.K. and Puri (2009), *Indian Economy,* Himalaya
4. Pareek Saroj (2003), *Textbook of Business Economics,* Sunrise Publishers
5. M Chakravarty, Estimating, Costing Specifications & Valuation
6. Joy P K, Handbook of Construction Management, Macmillan
7. B.S. Patil, Building & Engineering Contracts
8. Relevant Indian Standard Specifications.
9. World Bank Approved Contract Documents.
10. FIDIC Contract Conditions.
11. Acts Related to Minimum Wages, Workmen’s Compensation, Contract, and Arbitration
12. Typical PWD Rate Analysis documents.
13. UBS Publishers & Distributors, Estimating and Costing in Civil Engineering: Theory and Practice including Specification and Valuations,2016
14. Dutta, B.N., Estimating and Costing in Civil Engineering (Theory & Practice), UBS Publishers, 2016

On completion of the course, the students will:

- Have an idea of Economics in general, Economics of India particularly for public sector agencies and private sector businesses
- Be able to perform and evaluate present worth, future worth and annual worth analyses on one of more economic alternatives.
- Be able to carry out and evaluate benefit/cost, life cycle and breakeven analyses on one or more economic alternatives.
- Be able to understand the technical specifications for various works to be performed for a project and how they impact the cost of a structure.
- Be able to quantify the worth of a structure by evaluating quantities of constituents, derive their cost rates and build up the overall cost of the structure.
- Be able to understand how competitive bidding works and how to submit a competitive bid proposal.

ANNEXURE-I

SYLLABUS FOR BASKET OF ELECTIVE COURSES OF ELECTED TRACKS

IMPORTANT NOTE: ***Only keywords/topics of the course/subject is mentioned. This is in order to detail or condense as per the requirement and assign appropriate credits. Suggested credit for any course is either 2 or 3. Prerequisites are to be decided by the concerned faculty keeping in mind the track/thread/stream of courses taken by the student earlier.***

Systems Engineering & Economics: Introduction to the formulation and solution of civil engineering problems. Major topics are: engineering economy, mathematical modeling, and optimization. Techniques, including classical optimization, linear and nonlinear programming, network theory, critical path methods, simulation, decision theory, and dynamic programming are applied to a variety of civil engineering problems.
Prerequisite:

Engineering Risk & Uncertainty. Identification and modeling of non-deterministic problems in civil engineering design and decision making. Development of stochastic concepts and simulation models and their relevance to real design and decision problems in various areas of civil engineering.
Prerequisite:

Concrete Materials. Examines the influence of constituent materials (cements, aggregates and admixtures) on the properties of fresh and hardened concrete; Recycled aggregates recovered from construction and demolition wastes; M-Sand; Light-weight aggregates; Use of Fly Ash in concrete; Fibre-reinforced concrete with various types of metallic and non-metallic fibres; various types of concrete such as Self Compacting Concrete, High Performance Concrete, etc.; mix design; handling and placement of concrete; Effect of revibration of concrete; behavior of concrete under various types of loading and environment; test methods. Laboratory practice is an integral part of the course.
Prerequisite:

Pavement Materials. Soil - Classification, characteristics, compaction, evaluation of soil strength; stabilized pavement materials; Aggregates: requirements, properties and tests on road aggregates for flexible and rigid pavements. Bitumen: Origin, preparation, properties and tests, constitution of bituminous road binders; requirements; Criterion for selection of different binders.Bituminous Emulsions and Cutbacks: Preparation, characteristics, uses and tests,Bituminous Mixes: Mechanical properties: Resilient modulus, dynamic modulus and fatigue characteristics of bituminous mixes. bituminous mix design methods and specifications.Weathering and Durability of Bituminous Materials and Mixes.Performance based Bitumen Specifications; Superpave mix design method: design example problems. Cement Concrete for Pavement Construction: Requirements, and design of mix for CC pavement, IRC and IS specifications and tests, joint filler and sealer materials.
Prerequisite:

Pavement Design. Introduction: Types and component parts of pavements, Factors affecting design and performance of pavements. Highway and airport pavements.Stresses and Deflections in Flexible Pavements: Stresses and deflections in homogeneous masses. Burmister's two layer theory, three layer and multi-layer theories; wheel load stresses, various factors in traffic wheel loads; ESWL of multiple wheels. Repeated loads and EWL factors; sustained loads. Pavement behaviour under transient traffic loads.Flexible Pavement Design Methods For Highways and Airports: Empirical, semi-empirical and theoretical approaches, development, principle, design steps, advantages; design of flexible pavements as per IRC; Stresses in Rigid Pavements: Types of stresses and causes, factors influencing the stresses; general considerations in rigid pavement analysis, EWL; wheel load stresses, warping stresses, frictional stresses, combined stresses.Rigid Pavement Design: Types of joints in cement concrete pavements and their functions, joint spacings; design of CC pavement for roads and runways as per IRC, design of joint details for longitudinal joints, contraction joints and expansion joints. IRC method of design by stress ratio method. Design of continuously reinforced concrete pavements; Maintenance, repair and rehabilitation of pavements including design of bituminous and concrete overlays as per IRC
Prerequisite:

Geometric Design of Highways: Introduction: Classification of rural highways and urban roads. Objectives and requirements of highway geometric design; Design Controls: Topography, vehicle characteristics and design vehicle, driver characteristics, speed, traffic flow and capacity, levels of service, pedestrian and other facilities, environmental factors; Design Elements: Sight distances, Horizontal alignment - design considerations, stability at curves, super elevation, widening, transition curves; curvature at intersections, vertical alignment - grades, ramps, design of summit and valley curves, combination of vertical and horizontal alignment including design of hair pin bends, design of expressways, IRC standards and guidelines for design problems; Cross Section Elements: Right of way and width considerations, roadway, shoulders, kerbs traffic barriers, medians, frontage roads; Facilities for pedestrians, bicycles, buses and trucks, Pavement surface characteristics - types, cross slope, skid resistance, unevenness; Design Considerations: Design considerations for rural and urban arterials, freeways, and other rural and urban roads; Design Of Intersections: Characteristics and design considerations of at-grade intersections;; Rotary intersections; Grade separations and interchanges -; Design of Parking lots
Prerequisite:

Airport Planning and Design:Aircraft characteristics; Aircraft performance characteristics: Airport planning and air travel demand forecasting: Airport Site Selection; Geometric Design of the Airfield: Determination of Runway Capacity and Delay - Taxiway and Gate Capacity - Holding Aprons - Terminal Aprons – Airport drainage - Function of Airport Passenger and Cargo Terminal - Design of Air Freight Terminals - Airport access - Airport Landside planning - Capacity; Air Traffic Management: Navigational aids: ground based systems, satellite based systems – Air traffic control and surveillance facilities – Airfield lighting - air traffic management.
Prerequisite:

Intelligent Transportation Systems: Introduction to Intelligent Transportation Systems (ITS) – Definition of ITS and Identification of ITS Objectives, Historical Background, Benefits of ITS - ITS Data collection techniques – Detectors, Automatic Vehicle Location (AVL), Automatic Vehicle Identification (AVI), Geographic Information Systems (GIS), video data collection.Telecommunications in ITS – Importance of telecommunications in the ITS system, Information Management, Traffic Management Centres (TMC). Vehicle – Road side communication – Vehicle Positioning System; ITS functional areas – Advanced Traffic Management Systems (ATMS), Advanced Traveler Information Systems (ATIS), Commercial Vehicle Operations (CVO), Advanced Vehicle Control Systems (AVCS), Advanced Public Transportation Systems (APTS), Advanced Rural Transportation Systems (ARTS); ITS User Needs and Services – Travel and Traffic management, Public Transportation Management, Electronic Payment, Commercial Vehicle Operations, Emergency Management, Advanced Vehicle safety systems, Information Management; Automated Highway Systems - Vehicles in Platoons – Integration of Automated Highway Systems. ITS Programs in the World – Overview of ITS implementations in developed countries, ITS in developing countries.
Prerequisite:

Railway Engineering. Railway track gauge, alignment of railway lines, engineering surveys and construction of new lines, tracks and track stresses; rails, sleepers; ballast; subgrade and formation, rack fittings and fastenings, creep of rails, geometric design of track, curves and super-elevation, points and crossings, track junctions and simple track layouts; rail joints and welding of rails; track maintenance, track drainage; modern methods of track maintenance, rehabilitation and renewal of track; tractive resistance and power, railway stations and yards; railway tunneling; signaling and interlocking; maintenance of railways and high speed trains.
Prerequisite:

High Speed Rail Engineering. Development, engineering, design and construction of high-speed rail (HSR) passenger transport systems with particular emphasis on the unique engineering elements of HSR technology. Key elements of HSR systems and subsystems including: core systems (trains, power, signal, communication and control), track system and civil infrastructure (earthwork, bridges, viaducts and tunnels). Also covered are basic design and construction of HSR stations and rolling stock maintenance facilities.
Prerequisite:

Urban Transportation Planning: Urban morphology - Urbanization and travel demand – Urban activity systems and travel patterns – Systems approach – Trip based and Activity based approach - Urban Transportation Planning – Goals, Objectives and Constraints - Inventory, Model building, Forecasting and Evaluation - Study area delineation – Zoning - UTP survey; Trip generation models – Trip classification - productions and attractions – Trip rate analysis - Multiple regression models - Category analysis - Trip distribution models – Growth factor models, Gravity model and Opportunity modes; Modal split models – Mode choice behavior – Trip end and trip interchange models - Probabilistic models - Utility functions - Logit models - Two stage model. Traffic assignment – Transportation networks – Minimum Path Algorithms - Assignment methods – All or Nothing assignment, Capacity restrained assignment and Multi path assignment - Route-choice behavior; Land use transportation models – Urban forms and structures - Location models - Accessibility – Land use models - Lowry derivative models - Quick response techniques - Non-Transport solutions

for transport problems; Preparation of alternative plans - Evaluation techniques - Plan implementation - Monitoring - Financing of Project – urban development planning policy - Case studies.
Prerequisite:

Pavement Construction and Management: Flexible Pavement Construction: Earthwork, compaction and construction of embankments, specifications of materials, construction methods and field control checks for various types of flexible pavement materials in sub-base, base, binder and surface course layers and their choice; Cement Concrete Pavement Layers: Specifications and method of cement concrete pavement construction; Construction of interlocking block pavements, Quality control tests; Construction of various types of joints; Soil Stabilized Pavement Layers: Principles of gradation/proportioning of soil-aggregate mixes and compaction; Design factors, mix design, construction control and quality control checks for mechanical, soil-cement, soil-bitumen and soil-lime stabilization methods. Use of additives, Numerical problems on mix design and applications; Pavement Evaluation - Pavement Distress - Functional and structural condition of pavements, Pavement distress survey, Functional condition evaluation of pavements- Roughness, Skid Resistance. Structural evaluation of pavements - nondestructive testing, Benkelman beam and Falling Weight Deflectometer, Pavement strengthening based on deflection as per IRC, Maintenance and rehabilitation techniques; Pavement Management Systems - Pavement Management Systems- Components, structure, data requirements, Project level and Network level needs, Pavement performance prediction – concepts, modelling techniques– AASTHO, CRRI and HDM models, Budget forecasting for maintenance and rehabilitation, Ranking and optimization methodologies, life cycle costing,
Prerequisite:

Transportation Economics: Introductory Concepts in Transportation Decision Making: Overall transportation project development, budgeting, financial planning, the process of transportation project development, models associated with transportation impact evaluation; Transportation costs - Classification of transportation costs, transportation agency costs, transportation user costs, general structure and behavior of cost functions and road pricing. Estimating Transportation Demand and Supply - supply equilibration, dynamics of transportation demand and supply, elasticity of travel demand and supply, classification of elasticity; Vehicle operating costs: Fuel costs - Maintenance and spares, Depreciation - Crew costs - Value of travel time savings - Accident costs. Economics of traffic congestion - Pricing policy; Economic analysis of projects - Methods of evaluation - Cost-benefit ratio, first year rate of return, net present value, and internal-rate of return methods; Indirect costs and benefits of transport projects; Financing of road projects - methods – Private Public Partnership (PPP) - Toll collection - Economic viability of Design-Build-Operate-Transfer Schemes – Risk Analysis – Value for Money analysis - Case Studies.
Prerequisite:

Port and Harbour Engineering: Harbour Planning: Types of water transportation, water transportation in India, requirements of ports and harbours, classification of harbours, selection of site and planning of harbours, location of harbour, traffic estimation, master plan, ship characteristics, harbour design, turning basin, harbour entrances, type of docks, its location and number, Site investigations – hydrographic survey, topographic survey, soil investigations, current observations, tidal observations; Docks and Repair Facilities: Design

and construction of breakwaters, berthing structures - jetties, fenders, piers, wharves, dolphins, trestle, moles, Harbour docks, use of wet docks, design of wet docks, repair docks, lift docks, dry docks, keel and bilge blocking, construction of dry docks, gates for dry docks, pumping plant, floating docks, slipways, locks, size of lock, lock gates, types of gates; Navigational Aids: Requirements of signals, fixed navigation structures, necessity of navigational aids, light houses, beacon lights, floating navigational aids, light ships, buoys, radar; Dredging and Coastal Protection: Classification, types of dredgers, choice of dredger, uses of dredged materials, coastal erosion and protection, sea wall, revetment, bulkhead, coastal zone and beach profile; Port facilities: Port development, port planning, port building facilities, transit sheds, warehouses, cargo handling facilities, container handling terminal facilities, shipping terminals, inland port facilities. Inland waterways, Inland water transportation in India, classification of waterways, economics of inland waterways transportation, national waterways.
Prerequisite:

Traffic Engineering and Management: Traffic Forecast: General travel forecasting principles, different methods of traffic forecast - Mechanical and analytical methods, Demand relationships, methods for future projection; Design Hourly Volume For Varying Demand Conditions: Concept of Design vehicle units and determination of PCU under mixed traffic conditions, Price-volume relationships, demand functions. Determination of design hourly volume; critical hour concept;Highway Capacity: Factors affecting capacity, level of service; Capacity studies - Capacity of different highway facilities including unsignalised and signalised intersections. Problems in Mixed Traffic flow; Case studies; Accident Analysis: Analysis of individual accidents and statistical data; Methods of representing accident rate; Factors in traffic accidents; influence of roadway and traffic conditions on traffic safety; accident coefficients; Driver strains due to roadway and traffic conditions; Traffic Flow Theory: Fundamental flow relationship and their applications, Traffic flow theories and applications; Shock waves; Queuing theory and applications; Probabilistic Aspects Of Traffic Flow: Vehicle arrivals, distribution models, gaps and headway distribution models; gap acceptance merging parameters, delay models, applications; Simulation: Fundamental principle, application of simulation techniques in traffic engineering - formulation of simulation models, Case studies. Formulation of system models.
Prerequisite:

Public Transportation Systems: Public Transport: Definitions, modes of public transport and comparison, public transport travel characteristics, trip chaining, technology of bus, rail, rapid transit systems, basic operating elements; Transit Network Planning: Planning Objectives, principles, considerations, transit lines – types, geometry and characteristics, transit routes and their characteristics, timed transfer networks, prediction of transit usage, evaluation of network, accessibility considerations; Transit Scheduling: Components of scheduling process, determination of service requirements, scheduling procedure, marginal ridership, crew scheduling;Transit Agency and Economics: Organizational structure of transit agency, management and personnel, transit system statistics, performance and economic measures, operations, fare structure; Design of Facilities: Design of bus stops, design of terminals – principles of good layout, types of layout, depot location, twin depot concept, crew facilities and amenities.
Prerequisite:

Infrastructure Planning and Management: Introduction: Definition of basic terminologies, role of infrastructure in economic development, types of infrastructure, measurement of infrastructure capacity, bases for quantification of demand and supply of various types of infrastructure, Indian scenario in respect of adequacy and quality. Infrastructure Planning: Goals and objectives of infrastructure planning; Identification and quantification of the casual factors influencing the demand for infrastructure; review and application of techniques to estimate supply and demand for infrastructure; use of econometric, social and land use indicators and models to forecast the demand and level of service of infrastructure and its impact on land use; critical review of the relevant forecasting techniques; infrastructure planning to identify and prioritize preferred areas for development; Integration of strategic planning for infrastructure at urban, regional and national levels; case studies in infrastructure planning. Infrastructure Management: Concepts, Common aspects of urban and rural infrastructure management systems; pavement and bridge management systems, Integrated infrastructure management, Case studies; Emerging trends in infrastructure: Overview of Public-Private Sector Participation in infrastructure projects, Understanding stakeholders' concerns, regulatory framework, risk management in infrastructure projects, public policy for infrastructure Sectoral Overview: Highways, railways, waterways, airports, urban and rural infrastructure: roads, housing, water supply, sanitation – case study examples.
Prerequisite:

Construction Productivity. Definition of Productivity, Impact of productivities on construction duration and costs; Measuring productivities of construction equipment, Staff and Labour and typical benchmarks for the same; Productivity analysis from Daily Progress Reports; Lean Construction concepts of Value Adding activities, Non-Value Adding Activities and Non-Value Adding but Necessary Activities; Productivity measurements by special Lean Construction-oriented field methods such as Work Sampling, Takt time analysis, Foreman Delay Surveys; Productivity improvement measures such as Value Stream Mapping, Location-Based management Systems, 5S, good Housekeeping, etc.; use of specialist software such as Vico for productivity studies
Prerequisite:

Building Construction Practice. Specifications, details and sequence of activities and construction co-ordination – Site Clearance – Marking – Earthwork - masonry – stone masonry – Bond in masonry - concrete hollow block masonry – flooring – damp proof courses – construction joints – movement and expansion joints – pre cast pavements – Building foundations – basements – temporary shed – centering and shuttering – slip forms – scaffoldings – de-shuttering forms – Fabrication and erection of steel trusses – frames – braced domes – laying brick — weather and water proof – roof finishes – acoustic and fire protection; Sub Structure Construction- Techniques of Box jacking – Pipe Jacking -under water construction of diaphragm walls and basement-Tunnelling techniques – Piling techniques - well and caisson - sinking cofferdam - cable anchoring and grouting-driving diaphragm walls, sheet piles - shoring for deep cutting - well points -Dewatering and stand by Plant equipment for underground open excavation; Super Structure Construction- Launching girders, bridge decks, off shore platforms – special forms for shells - techniques for heavy decks – in-situ pre-stressing in high rise structures, Material handling - erecting light weight components on tall structures - Support structure for heavy Equipment and conveyors - Erection of articulated structures, braced domes and space decks;
Prerequisite:

Construction Equipment & Automation*:*Conventional construction methods Vs Mechanized methods and advantages of latter; Equipment for Earthmoving, Dewatering; Concrete mixing, transporting & placing; plastering machines; Prestressing jacks and grouting equipment; Cranes, Hoists and other equipment for lifting; Equipment for transportation of materials. Equipment Productivities; Use of Drones for spread out sites; Use of robots for repetitive activities
Prerequisite:

Contracts Management. Contract Management – Introduction, Importance of Contracts, Overview of Contract Management, Overview of Activities in Contract Management; Planning and People- Resource Management; Types of Contracts, Parties to a Contract; Contract Formation, Formulation of Contract, Contract Start-Up, Managing Relationships; Common contract clauses (Notice to proceed, rights and duties of various parties, notices to be given, Contract Duration and Price. Performance parameters; Delays, penalties and liquidated damages; Force Majeure, Suspension and Termination. Changes & variations, Notices under contracts; Conventional and Alternative Dispute Resolution methods. Various Acts governing Contracts; Contract Administration and Payments- Contract Administration, Payments; Contract Management in Various Situations- Contract Management in NCB Works, Contract Management in ICB Works Contracts, Contract of Supply of Goods-Design, Supply and Installation Contracts, Contract Management in Consultancy,; Managing Risks and Change- Managing Risks, Managing Change; Contract Closure and Review-Ending a Contract, Post-Implementation Review; Legal Aspects in Contract Management-Contract Management Legal View, Dispute Resolution, Integrity in Contract Management; Managing Performance- Introduction, Monitoring and Measurement

Construction Project Planning& Systems. Definition of Projects; Stages of project planning: pre-tender planning, pre-construction planning, detailed construction planning, role of client and contractor, level of detail. Process of development of plans and schedules, work break-down structure, activity lists, assessment of work content, concept of productivities, estimating durations, sequence of activities, activity utility data; Techniques of planning- Bar charts, Gantt Charts. Networks: basic terminology, types of precedence relationships, preparation of CPM networks: activity on link and activity on node representation, computation of float values, critical and semi critical paths, calendaring networks.PERT-Assumptions underlying PERT analysis, determining three time estimates, analysis, slack computations, calculation of probability of completion. Allocation of Resources- materials, equipment, staff, labour and finance; resource levelling and optimal schedules; Project organisation, documentation and reporting systems. Control & monitoring; Temporary Structures in Construction; Construction Methods for various types of Structures; Major Construction equipment; Automation & Robotics in Construction; Modern Project management Systems; Advent of Lean Construction; Importance of Contracts Management; Planning and organizing construction site and resources- Site: site layout including enabling structures, developing site organization, Documentation at site; Manpower: planning, organizing, staffing, motivation; Materials: concepts of planning, procurement and inventory control; Equipment: basic concepts of planning and organizing; Funds: cash flow, sources of funds; Histograms and S-Curves. Earned Value; Resource Scheduling- Bar chart, line of balance technique, resource constraints and conflicts; resource aggregation, allocation, smoothening and levelling. Common Good Practices in Construction; *Project Monitoring & Control-* Supervision, record keeping, periodic progress reports, periodical progress

meetings. Updating of plans: purpose, frequency and methods of updating. Common causes of time and cost overruns and corrective measures. Basics of Modern Project management systems such as Lean Construction; Use of Building Information Modelling (BIM) in project management; Quality control: concept of quality, quality of constructed structure, use of manuals and checklists for quality control, role of inspection, basics of statistical quality control. Safety, Health and Environment on project sites: accidents; their causes, effects and preventive measures, costs of accidents, occupational health problems in construction, organizing for safety and health.
Prerequisite:

Construction Cost Analysis. Introduction to the application of scientific principles to costs and estimates of costs in construction engineering; concepts and statistical measurements of the factors involved in direct costs, general overhead costs, cost markups and profits; and the fundamentals of cost recording for construction cost accounts and cost controls.
Prerequisite:

Repair & Rehabilitation of Structures. Maintenance and Repair Strategies Maintenance, Repair and Rehabilitation, Facets of Maintenance, importance of Maintenance, Various aspects of Inspection, Assessment procedure for evaluating a damaged structure, causes of deterioration; Strength and Durability Of Concrete- Quality assurance for concrete – Strength, Durability and Thermal properties, of concrete – Cracks, different types, causes – Effects due to climate, temperature, Sustained elevated temperature, Corrosion – Effects of cover thickness; Special Concretes- Polymer concrete, Sulphur infiltrated concrete, Fibre reinforced concrete, High strength concrete, High performance concrete, Vacuum concrete, Self-compacting concrete, Geopolymer concrete, Reactive powder concrete, Concrete made with industrial wastes; Techniques for Repair and Protection Methods- Non-destructive Testing Techniques, Epoxy injection, Shoring, Underpinning, Corrosion protection techniques – Corrosion inhibitors, Corrosion resistant steels, Coatings to reinforcement, cathodic protection; Repair, Rehabilitation and Retrofitting of Structures- Evaluation of root causes; Underpinning & shoring; some simple systems of rehabilitation of structures; Guniting, shotcreting; Non-Destructive testing systems; Use of external plates, carbon fibre wrapping and carbon composites in repairs.Strengthening of Structural elements, Repair of structures distressed due to corrosion, fire, Leakage, earthquake – Demolition Techniques – Engineered demolition methods – Case studies.
Prerequisite:

Sustainable Construction Methods. Types of foundations and construction methods; Basics of Formwork and Staging; Common building construction methods (conventional walls and slabs; conventional framed structure with blockwork walls); Modular construction methods for repetitive works; Precast concrete construction methods; Basics of Slip forming for tall structures; Basic construction methods for steel structures; Basics of construction methods for Bridges; Identification of cutting edge sustainable construction materials, technologies, and project management strategies for use in the construction industry and evaluation of their potential to reduce the negative environmental impacts of construction activity. Examination of the current LEED for New Construction rating system, and case study analysis of highly successful recent "green construction projects" through student team assignments and presentations. Preparation for the LEED Green Associate professional licensing exam.
Prerequisite:

Engineering Materials for Sustainability. Environmental impact of materials; life-cycle assessment; material selection to optimize performance; design, evaluation, and production of green construction materials.
Prerequisite:

Ecological Engineering. Characteristics of rivers and lakes which affect the management of domestic and industrial wastewaters; chemical hazards assessment, surveillance and biomonitoring, and review of regulations governing effluents.
Prerequisite:

Stream Ecology. Description of physical, chemical, and biological characteristics in streams and rivers including an integrated treatment of the environmental factors affecting the composition and distribution of biota; emphasizes the application of ecological engineering principles in aquatic ecosystem protection.
Prerequisite:

Environmental Systems. Introduction to the concepts and applications of environmental systems analysis. Application of mathematical programming and modeling to the design, planning and management of engineered environmental systems, regional environmental systems, and environmental policy. Economic analysis, including benefit-cost analysis and management strategies. Concepts of tradeoff, non- inferior sets, single and multi-objective optimization. Practical application to case studies to convey an understanding of the complexity and data collection challenges of actual design practice.
Prerequisite:

Water Quality Engineering. Fundamental theory underlying the unit processes utilized in the treatment of water for domestic and industrial usage, and in the treatment of domestic and industrial wastewaters.

Transport of water and wastewater. The objective of the course is to make students gain insight into how the water and wastewater gets transported through conduits and open channels, and use the same for the design, operation and maintenance of these systems. Water Supply Systems: Storage requirements, impounding reservoirs, intake structures, pipe hydraulics, design of distribution systems, distribution and balancing reservoirs, pipe materials, appurtenances, design for external loads, maintenance and operation. Sanitary Sewerage Systems: Flow estimation, sewer materials, hydraulics of flow in sewers, sewer lay out, sewer transitions, materials for sewers, appurtenances, manholes, sewer design, conventional and model based design, sewage pumps and pumping stations, corrosion prevention, operation and maintenance, safety. Storm water Drainage Systems: Drainage layouts, storm runoff estimation, hydraulics of flow in storm water drains, materials, cross sections, design of storm water drainage systems, inlets, storm water pumping, operation and maintenance

Environmental Laws and Policy. Overview of environment, nature and eco system, Concept of laws and policies, Origin of environmental law, Introduction to environmental laws and policies, Environment and Governance, sustainable development and environment, understanding climate change, carbon crediting, carbon foot print etc., Introduction to trade and environment. International environmental laws, Right to Environment as Human Right, International Humanitarian Law and Environment, environment and conflicts management, Famous international protocols like Kyoto.

Physico-Chemical Processes for water and wastewater treatment. The Objective of this course is to provide an in depth understanding of physical and physico-chemical processes used for water and wastewater treatment systems and to provide capability to design such systems. Water purification in natural systems, physical processes, chemical processes and biological processes. Primary, secondary and tertiary treatment. Unit operations, unit processes. Aeration and gas transfer**.** Sedimentation, different types of settling, sedimentation tank design. Coagulation and flocculation, coagulation processes, stability of colloids, destabilization of colloids, destabilization in water and wastewater treatment, transport of colloidal particles, design aspects. Filtration: filtration processes, Hydraulics of flow through porous media, Rate control patterns and methods, Filter effluent quality parameters, mathematical model for deep granular filters, slow sand filtration, rapid sand filtration, pre-coat filtration, design aspects. Disinfection: Types of disinfectants, Kinetics of disinfection, chlorination and its theory, Design of Chlorinators. Precipitation: Hardness removal, Iron, Mn, and heavy metal removal; Adsorption, adsorption equilibria and adsorption isotherm, rates of adsorption, Sorption kinetics in batch reactors, continuous reactors, factors affecting adsorption. Ion Exchange-exchange processes, materials and reactions, methods of operation, Application, design aspects. Membrane Processes, Reverse osmosis, Ultrafiltration, Electrodyalisis

Biological processes for contaminant removal. Understanding of basics of microbiology, metabolism and energetic, bio kinetic parameter, reactors and reactor analyses. Characterization of waste. Aerobic, anaerobic and anoxic systems. Suspended and attached growth biological systems. Activated Sludge processand process modifications, Process design considerations, Treatment Ponds and aerated Lagoons, aerobic pond, facultative pond, anaerobic ponds, polishing ponds, constructed wet lands etc. Attached Growth Biological Treatment Systems, Trickling Filters, Rotating Biological Contactors, Activated Biofilters, Moving bed biological reactor (MBBR), Sequential Batch reactors (SBR), Membrane Biological Reactors (MBR) etc. Anaerobic processes, Process fundamentals, Standard, high rate and hybrid reactors, Anaerobic filters, Expanded /fluidized bed reactors, Upflow anaerobic sludge blanket reactors, Performance and design aspects, Expanded granular bed reactors, Two stage/phase anaerobic reactors. Sludge Digestion, anaerobic digestion, aerobic digestion

Rural water supply and onsite sanitation systems. Attributes of water supply systems, drinking water quality. Relationships between diseases and water quality, hygiene and sanitation. Need for water treatment. Point of use water treatment systems, filters, bio-sand filters, disinfection systems for rural areas, chlorination, Solar disinfection systems, removal of arsenic, fluoride and iron.Onsite sanitation systems: Nexus between water quality and sanitation. Importance of hydrogeology on selection of onsite sanitation systems, Design of Septic tanks, single pit and double pit toilets. Small bore systems, bio digesters, reed beds, constructed wetlands, sludge/septage management systems.

Air and Noise Pollution Control. Air pollutants, Sources, classification, Combustion Processes and pollutant emission, Effects on Health, vegetation, materials and atmosphere, Reactions of pollutants in the atmosphere and their effects-Smoke, smog and ozone layer disturbance, Greenhouse effect. Air sampling and pollution measurement methods, principles and instruments, Ambient air quality and emission standards, Air pollution indices, Air Act, legislation and regulations, control principles, Removal of gaseous pollutants by adsorption, absorption, reaction and other methods. Particulate emission control, settling chambers, cyclone separation, Wet collectors, fabric filters, electrostatic precipitators and other removal methods like absorption, adsorption, precipitation etc. Biological air pollution control technologies, Indoor air quality. Noise pollution: Basics of acoustics and specification of sound; sound power, sound intensity and sound pressure levels; plane, point and line sources, multiple sources; outdoor and indoor noise propagation; psychoacoustics and noise criteria, effects of noise on health, annoyance rating schemes; special noise environments: Infrasound, ultrasound, impulsive sound and sonic boom; noise standards and limit values; noise instrumentation and monitoring procedure. Noise indices. Noise control methods

Solid and hazardous waste management. Solid Wastes: Origin, Analysis, Composition and Characteristics. Integrated Solid Waste Management System: Collection, Storage, Segregation, Reuse and Recycling possibilities, Transportation, Treatment / Processing and Transformation Techniques, Final Disposal. Management of: Municipal, Biomedical, Nuclear, Electronic and Industrial Solid Wastes and the rules and regulations. Introduction to Hazardous wastes, Definition of Hazardous waste, The magnitude of the problem; Hazardous waste: Risk assessment, Environmental legislation, Characterization and site assessment, Waste minimization and resource recovery, Transportation of hazardous waste, Physical, chemical and biological treatment, Ground water contamination, Landfill disposal, Current Management Practices, Environmental audit, Pollution Prevention, Facility Development and operation, Site Remediation: Quantitative risk assessment, site and subsurface characterization, Containment, remedial alternatives.

Water and Air Quality Models. Introduction to Mathematical Models: water quality model development, calibration and verification cost: benefit analysis using models, Model requirements and limitations. D.O. Models for Streams: Dissolved oxygen model for streams sources and sinks of dissolved oxygen estimation of system parameters Streeter Phelps model oxygen 'sag' curve-determination of deoxygenation and re-aeration coefficients- Benthal oxygen demand mass transport mechanisms- Models for Estuary and Lakes: Physical chemical and biological processes in estuaries; Air quality models: Micrometeorological processes, wind rose, dispersion, coefficients and stability classes, Gaussian and dispersion model, Stack height computation, Regional air quality models, Source inventories and significance .

Environmental impact assessment and life cycle analyses. Evolution of EIA: Concepts of EIA methodologies, Screening and scoping; Rapid EIA and Comprehensive EIA; General Framework for Environmental Impact Assessment, Characterization and site assessment. Environmental Risk Analysis, Definition of Risk, Matrix Method. Checklist method, Fault tree analysis, Consequence Analysis; Socioeconomic aspects, measures of effectiveness of pollution control activities; Environmental Legislation; Introduction to Environmental Management Systems; Environmental Statement - procedures; Environmental Audit: Cost Benefit Analysis; Life Cycle Assessment; Resource Balance, Energy Balance & Management Review; Operational Control; Case Studies on EIA.

Hydraulic Structures/Irrigation Engineering: This course should discuss key issues in designing irrigation channels and hydraulic structures used in irrigation systems
Estimation of crop water requirement; Design of lined and unlined channels; Analysis for surface and sub-surface flow at hydraulic structures; Design of barrages and weirs; Design of Head and cross regulators; Design of canal falls, transitions and cross drainage works; Design principles for gravity and earthen dams

Pipeline Engineering: The course should cover key issues for designing and operating pipelines for transmission and distribution of water; Analysis of flow in water transmission and water distribution systems (pump & gravity); optimal design and operation of systems for achieving different goals (including latest tools available for optimization); Extended period simulations, Software for WDN analysis and design, Rehabilitation of pipeline systems; Water auditing, online monitoring and control, leak and burst detection; transient analysis and surge protection; Appurtenances (valves / flow meters etc.); Selection of pipe material; Jointing details; Pipe laying and testing; Structural design for buried and surface mounted pipes
Pre-Requisite: Basic course in Hydraulic Engineering

Unsteady Open Channel Flow: This course should discuss how to analyze for unsteady flows in open channels; Derivation of 1-D and 2-D shallow water flow equations; Consideration for non-hydrostatic pressure distribution; Basics of numerical methods: Finite-Difference and Finite Element Methods; Latest shock capturing Finite Volume methods for solving 1-D and 2-D shallow water flow equations; Dambreak flow; Flood routing in large channel networks, Flood routing in compound channels; Flood routing in channels with flood plains, Surface irrigation flow modeling
Pre-Requisite: Basic course in Hydraulic Engineering

River Engineering: Knowledge about river behavior is essential for practicing hydraulic and water resources engineers. River Morphology (Bars; Bends and Meanders, Thalweg; Braiding; Bifurcations etc.); Sediment Transport Mechanics (Bed forms, Bed Load transport, Transport of suspended sediment, Critical Shear stress, Sediment Transport Equations); Aggradation and Degradation; Local Scour at Bridge Piers and other Hydraulic Structures. Measurements in Rivers (Stage measurements, Channel geometry, Discharge, Sediment samplers and suspended and bed load measurement), Physical river Models (fixed and movable bed models; sectional models, distorted Models), Mathematical models for aggradations, degradation and local scour, River Protection and Training Works (Revetments, Dikes, Gabions, Spurs, Bank Protective measures and Bed control structures), Design of river training and flood protection structures, Diversion and Cofferdams; River regulations systems; Dredging and Disposal, River restoration

Hydraulic Modeling: The main objective of this course is to introduce various concepts which will help in designing physical hydraulic models. Basics of Hydraulic Modelling (similarity mechanics, model laws, distinction between numerical and hydraulic models, classification of hydraulic modelling, materials used in the model, scale effect, design, construction, operation and interpretation of the results); Role of instrumentation and data processing; Gravity dominated models (modelling of energy dissipaters, overflow spillways, siphon spillways, bridge piers, vortex formation, cavitation, flow induced vibrations); Gravity friction models: (pumped flow models, ship models, surge tank models); Friction dominated models; River models with fixed and mobile bed; Basin and reservoir models; Tidal models with fixed and mobile bed; estuarine models; harbor and breakwater models, models of offshore structures; Hybrid and Analogue models; Scope and limitations of hydraulic modelling, complementary aspects of numerical and hydraulic modelling.

Basics of Computational Hydraulics. Derivation of governing equations for flow and transport in surface and sub-surface (saturated and unsaturated flow); Equations for reactive transport; Coupled surface and sub-surface flow models; Basics of finite difference, finite element and finite volume methods (consistency, stability, convergence, order of accuracy, computational efficiency); application of numerical methods for solving flow and transport equations, fully coupled and iteratively coupled models; Model simplification, Parameter estimation (Model calibration and validation), Computational Fluid Dynamics (CFD) software for three-dimensional turbulent flow modeling, Software for sub-surface flow simulation

Transients in Closed Conduits: This course should cover key issues for understanding the unsteady flow in pipes (water hammer) and designing for surge protection**;** Differential equations for unsteady pipe flow; Characteristic method for solution; Formulation of boundary conditions; transients in pumping mains (power failure; pump start up); transients in penstocks of hydro-electric schemes; analysis for transient control using surge tanks; air chambers; air valves; pressure regulating valves etc.; Emphasis should be on development of computer programs for transient analysis; awareness about commercially available software for transient analysis
Pre-Requisite: Basic course in Hydraulic Engineering

Groundwater Engineering: The main objective is to provide sufficient knowledge to the students about the groundwater hydrology, well hydraulics and well construction, geo-physical explorations, groundwater quality and management of groundwater resources; Problems and perspectives regarding groundwater in India; Hydrogeology: Darcy’s Equation; flow characteristics; general flow equations; unsaturated flow; Well Hydraulics: Steady and unsteady radial flows in aquifers; partially penetrating wells; multiple well systems; characteristic well losses; specific capacity, Surface and Subsurface investigations (Geologic methods; remote sensing; geophysical explorations; electrical resistivity and seismic refraction), Water Wells: Construction; completion, development, protection and rehabilitation of wells; Groundwater quality; Groundwater Management: Basin management, investigations, conjunctive use, modeling, artificial recharge; Saline water intrusion

Surface Hydrology. Study of descriptive and quantitative hydrology dealing with the distribution, circulation, and storage of water on the earth's surface; discusses principles of hydrologic processes and presents methods of analysis and their applications to engineering and environmental problems.
Prerequisite:

Environmental Fluid Mechanics. Incompressible fluid mechanics with particular emphasis on topics in analysis and applications in civil engineering areas; primary topics include principles of continuity, momentum and energy, kinematics of flow and stream functions, potential flow, laminar motion, turbulence, and boundary-layer theory.
Prerequisite:

Hydraulic Analysis and Design. Hydraulic analysis and design of engineering systems: closed conduits and pipe networks; hydraulic structures, including spillways, stilling basins, and embankment seepage; selection and installation of hydraulic machinery.
Prerequisite:

Urban Hydrology and Hydraulics. Hydraulic analysis and design of urban, highway, airport, and small rural watershed drainage problems; discussion of overland and drainage channel flows; hydraulics of storm-drain systems and culverts; determination of design flow; runoff for highways, airports, and urban areas; design of drainage gutters, channels, sewer networks, and culverts.
Prerequisite:

Groundwater. Physical properties of groundwater and aquifers, principles and fundamental equations of porous media flow and mass transport, well hydraulics and pumping test analysis, role of groundwater in the hydrologic cycle, groundwater quality and contamination.
Prerequisite:

Water Resources Field Methods. Scientific principles of measurement technologies and protocols used for water-resources measurements and experimental design of field-scale water-resources and environmental studies. Planning field studies; instruments and protocols for surface-water, ground-water, and water-quality sampling; description of data quality. One-half-day laboratory field trips to streamflow monitoring stations and groundwater monitoring wells nearby.
Prerequisite:

Structural Analysis-I. Direct stiffness method of structural analysis; fundamentals and algorithms; numerical analysis of plane trusses, grids and frames; virtual work and energy principles; introduction to the finite element method for plane stress and plane strain.
Prerequisite:

Structural Analysis-II. Analysis of building frames; Kani's, moment distribution and other methods and Approximate methods; Stiffness matrix method; Application to simple problems of beams and frames; Flexibility matrix method; Application to simple problems of beams and frames; Moving loads for determinate beams; Different load cases, Influence lines for forces for determinate beams; Influence lines for pin-jointed trusses; Influence lines for indeterminate beams using Muller Breslau principle. Influence lines for Arches and stiffening girders.

Prerequisite:

Advanced Structural Analysis. Elasticity: Introduction, Components of strain and strain, Hooke's law, Plane stress and plane strain, Equations of equilibrium and compatibility, Boundary conditions, Two dimensional problems in rectangular and polar coordinates, Bending of simple and cantilever beams; Model Analysis: Structural similitude, Direct and indirect model analysis, Model material and model making, Measurement for forces and deformations; Introduction to Finite element method for structural analysis; Review of principle of virtual work, Ritz method, Discretization of domain, Basic element shape,

Discretization process; Application of finite element method to one and two- dimensional plane stress strain elements.
Prerequisite:

Structural Mechanics. Beams under lateral load and thrust; beams on elastic foundations; virtual work and energy principles; principles of solid mechanics, stress and strain in three dimensions; static stability theory; torsion; computational methods.
Prerequisite:

Construction Engineering Materials. Design, production, application, specification, and quality control of construction materials unique to civil engineering. Stones, bricks, mortars, Plain, Reinforced & Prestressed Concrete, Construction Chemicals; Structural Steel, High Tensile Steel, Carbon Composites; Plastics in Construction; 3D printing; Recycling of Construction & Demolition wastes
Prerequisite:

Design of Steel Structures. Properties of materials; loads and stresses, Design of semi-rigid, rigid and moment resistant connections; Built-up sections Design of tension members subjected to axial tension and bending, splicing of tension member, Design of compression members, Beam-column connections, Design of columns and their bases Design of flexural members and Plate girder; loads, specification and design Industrial buildings; loads, design of purlins, trusses, bracings; gantry girders; Introduction to Plastic analysis; Simple cases of beams and frames; All design steps/process to as per the most recent BIS code of practices
Prerequisite:

Metal Structure Behavior- I. Introduction to the design of metal structures; behavior of members and their connections; and theoretical, experimental, and practical bases for proportioning members and their connections.
Prerequisite:

Metal Structure Behavior-II. Metal members under combined loads; connections, welded and bolted; moment- resistant connections; plate girders, conventional behavior, and tension field action.
Prerequisite:

Reinforced Concrete. Study of the strength, behavior, and design of reinforced concrete members subjected to moments, shear, and axial forces; extensive discussion of the influence of the material properties on behavior.
Prerequisite:

Concrete Technology. Concrete; Properties of ingredients, tests, Production of concrete, mixing, compaction curing, Properties of fresh concrete; Defects in Concrete, Concrete additives.; Behavior of concrete in tension and compression, shear and bond, Influence of various factors on test results, Time dependent behavior of concrete -creep, shrinkage and fatigue; Concrete mix design; Proportioning of concrete mixes, basic considerations, cost specifications, factors in the choice of mix proportion, different method of mix design. Quality control, Behavior of concrete in extreme environment; temperature problem in concreting, hot weather, cold weather and under water conditions, Resistance to freezing,

sulphate and acid attack, efflorescence, fire resistance; Inspection and testing of concrete-Concrete cracking, types of cracks, causes and remedies Non-destructive tests on concrete; Chemical tests on cement and aggregates; Special concrete; types and specifications, Fibre reinforced and steel Fibre reinforced concrete, Polymer concrete, Use of admixtures; Deterioration of concrete and its prevention Repair and rehabilitation.
Prerequisite:

Design of Concrete Structures-I. Study of the strength, behavior, and design of indeterminate reinforced concrete structures, Load and stresses, load combinations, Working stress and limit state approach. Analysis and design of sections in bending – working stress and limit state method, Rectangular and T-sections, Beams with reinforcement in compression, One-way slab. Design for shear and bond, Mechanism of shear and bond failure, Design of shear using limit state concept, Development length of bars; Design of sections in torsion. Design of two-way slabs; Design of flat slab – direct method; Circular slab; Slab type staircase, Placement of reinforcement in slabs; Voided slab. Design of compression members, Short column, Columns with uni-axial and bi-axial bending; Long columns, use of design charts. Design of foundation; Wall footing, Isolated and combined footing for columns. All designs to be as per the most recent BIS standards as applicable
Prerequisite:

Design of Concrete Structures-II. Design of continuous beams and building frames, Moment redistribution, Estimation of wind and seismic loads, Desirable features of earthquake resistant construction, Detailing for earthquake resistant construction – ductility criteria; Water tank and staging; Introduction, Design criteria, Design of rectangular and circular water tank, Design of
Intze tank, Staging for overhead tank; Introduction to bridge engineering, Investigation for bridges, IRC loadings, Design of slab culvert; Design of Masonry walls and columns; Pre-stressed concrete, Introduction, pre-stressing system, losses in pre-stress, Design of simple span girders, Design of end block; Design of staircases; Design of cantilever and counter-forte type retaining wall; All design steps/process to as per the most recent BIS code of practices
Prerequisite:

Bridge Engineering. General; classification of bridges, site selection, geometric and hydraulic design consideration, loading standards for highway and railway bridges, general design consideration; optimum spans; Concrete bridges: culverts; Slab, T-beam, box girder bridges, balanced cantilever bridge, cable stayed bridge, extrados bridges; arch bridge; Special requirements for Prestressed Concrete bridges; Steel bridges: plate girder bridge, truss bridge, suspension cable bridge, cable stayed bridge; Substructures: design of piers and abutments, pile and well foundations, bearings and expansion joints, special wearing coats; seismic design considerations; Aerodynamic stability considerations; special durability measures; provisions for inspection and maintenance;
Prerequisite:

Construction Practice. Building planning, site selection, orientation from environmental and other factors, principles of planning buildings, open air spaces, requirement of parts of buildings, lighting and ventilation, requirements of various rooms, Building bye laws. Components of building and their purpose and types; foundations, walls, columns, roofs,

doors, windows; Bands and openings in the buildings; seismic requirements; Mechanical, Electrical & Plumbing (MEP) works in buildings; Vertical transport in structures; Building finishes; Basic design of foundation of buildings, Terms used in brick masonry, Bonds and types of mortars. Excavation, dewatering, shoring, underpinning and scaffolding, drilling, blasting, well sinking and pile driving, cofferdams, form work-fabrication and use. Construction techniques for special structures such as slip forming and other special formwork systems for high-rise buildings, Damp proofing; causes and effect of dampness, materials and methods of damp proofing; Termite proofing: pre and post construction treatment; Thermal insulation, methods of thermal insulation, thermal insulation of roofs and exposed walls; Doors and windows, Staircases: parts and type of stairs, dimensioning of stair case. Internal and external painting- types and methods of application; various types of finishes; Fire protection- fire hazards, characteristics of fire-resisting materials and common building materials; Cracks in walls, floors and ceilings-causes and repairs techniques; Routine maintenance of buildings and structures.
Prerequisite:

Design of Structural Systems. The whole structural design process including definition of functional requirements, selection of structural scheme, formulation of design criteria, preliminary and computer- aided proportioning, and analysis of response, cost, and value.
Prerequisite:

Reliability Analysis of Structures. Role of reliability in civil engineering; Historical background, random events, random variables, model uncertainty; Common probabilistic models; Important statistical parameters and their estimations, normal, lognormal, extreme value distribution; Fundamental concept of structural reliability; Derivation of stress-strength interface equation, graphical representation, Cornel reliability index, reliability and failure probability computations for simple linear functions; Second moment concepts, First order second moment theory, Hasofer-Lind transformation, Linear and non-linear limit state functions, Solution schemes, geometric interpretation of solution scheme, Rackwitz-Fiessler transformation, First order reliability method; Stochastic models for material strength and loads, Reliability assessment of structural component and simple civil engineering structures.
Prerequisite:

Masonry Structures. Introduction to analysis, design and construction of masonry structures. Mechanical properties of clay and concrete masonry units, mortar, and grout. Compressive, tensile, flexural, and shear behavior of masonry structural components. Strength and behavior of unreinforced bearing walls. Detailed design of reinforced masonry beams, columns, structural walls with and without openings, and complete lateral-force resisting building systems.
Prerequisite:

Prestressed Concrete. Study of strength, behavior, and design of prestressed reinforced concrete members and structures, with primary emphasis on pretensioned, precast construction; emphasis on the necessary coordination between design and construction techniques in prestressing.
Prerequisite:

Wood Structures. Mechanical properties of wood, stress grades and working stresses; effects of strength- reducing characteristics, moisture content, and duration of loading and causes of wood deterioration; glued- laminated timber and plywood; behavior and design of connections, beams, and beam-columns; design of buildings and bridges; other structural applications: trusses, rigid frames, arches, and pole-type buildings; and prismatic plates and hyperbolic paraboloids.
Prerequisite:

Structural Dynamics. Analysis of the dynamic response of structures and structural components to transient loads and foundation excitation; single-degree-of-freedom and multi-degree-of-freedom systems; response spectrum concepts; simple inelastic structural systems; and introduction to systems with distributed mass and flexibility.
Prerequisite:

Earthquake Engineering. Theory of Vibrations; Concept of inertia and damping - Types of Damping - Difference between static forces and dynamic excitation - Degrees of freedom - SDOF idealization - Equations of motion of SDOF system for mass as well as base excitation - Free vibration of SDOF system - Response to harmonic excitation - Impulse and response to unit impulse - Duhamel integral; Multiple Degree of Freedom System; Two degree of freedom system - Normal modes of vibration - Natural frequencies - Mode shapes - Introduction to MDOF systems - Decoupling of equations of motion - Concept of mode superposition (No derivations); Elements of Seismology; Causes of Earthquake - Geological faults - Tectonic plate theory - Elastic rebound – Epicentre; Hypocentre - Primary, shear and Raleigh waves - Seismogram - Magnitude and intensity of earthquakes - Magnitude and Intensity scales - Spectral Acceleration - Information on some disastrous earthquakes; Response of Structures to Earthquake;Response and design spectra - Design earthquake - concept of peak acceleration - Site specific response spectrum - Effect of soil properties and damping - Liquefaction of soils - Importance of ductility - Methods of introducing ductility into RC structures Design Methodology IS 1893, IS 13920 and IS 4326 - Codal provisions - Design as per the codes - Base isolation techniques - Vibration control measures - Important points in mitigating effects of earthquake on structures
Prerequisite:

Industrial Structures. Industrial steel building frames: Types of frames, bracing, crane girders and columns, workshop sheds, trussed bents, Pressed steel tank, circular tank; Transmission and Communication towers: Types and configuration, Analysis and design; Chimneys; Loads and stresses in chimney shaft, Earthquake and wind effect, Stresses due to temperature difference, combined effect of loads and temperature, temperature. Design of chimney; Silos and Bunkers; Jassen's theory, Airy's theory, Shallow and deep bins, Rectangular bunkers with slopping bottom, Rectangular bunkers with high side walls; Steel stacks; introduction, force acting on a steel stack, design consideration, design example of stacks; Concrete Shell Structures: Folded plate and cylindrical shell structures; Introduction, structural behaviour of long and short shells, beam and arch action, analysis and design of cylindrical shell structures, Analysis and design of folded plates; Machine foundations; introduction, machine vibration, structural design of foundation to rotary machines, impact machines, vibration characteristics, design consideration of foundation to impact machine, grillage, pile and raft foundation.
Prerequisite:

Foundation Engineering. Analysis and design of foundations, types of foundations, bearing capacity and settlement of foundations; ground movements due to construction; analysis and design of excavations, retaining walls, cuts & excavations and sheet piles, slopes and underground structures.
Prerequisite:
Reference books:

- A. Singh, Modern Geotechnical Engineering, 3rd Ed., CBS Publishers, New Delhi, 1999.
- B.M. Das, Principles of Foundation Engineering, 5th Ed., Thomson Asia, Singapore, 2003.
- N. Som, Theory and Practice of Foundation Design, Prentice Hall, New Delhi, 2003.

After successful completion of this course, the students would:

- learn about types and purposes of different foundation systems and structures.
- Have an exposure to the systematic methods for designing foundations.
- Be able evaluate the feasibility of foundation solutions to different types of soil conditions considering the time effect on soil behaviour.
- have necessary theoretical background for design and construction of foundation systems.

Soil Mechanics-I. Composition and structure of soil; water flow and hydraulic properties; stress in soil; compaction and compressibility of soils; consolidation characteristics, settlement analysis; shear strength of soils; basics of unsaturated soils; experimental measurements.
Prerequisite:
Reference books:

- Soil Mechanics by Craig R.F., Chapman & Hall
- Principles of Geotechnical Engineering, by Braja M. Das, Cengage Learning

On successful completion of this course, the students:

- Should be able to assess soil behavior with the mineralogy present and advanced soil testing of soils such as in thermal, chemical, magnetic fields.
- Should be able to do seepage analysis for finding discharge calculation and stability of structure.

Should have knowledge about stress paths and get introduced to critical state soil mechanics

- Should be in a position to do various laboratory experiments to determine design parameters according field application.

Soil Mechanics-II. Application of soil mechanics to determine earth pressures, analysis of retaining walls, cuts & excavations and sheet piles, stability of slopes, instrumentation.
Prerequisite:
Reference books:

- Soil Mechanics by Craig R.F., Chapman & Hall
- Principles of Geotechnical Engineering, by Braja M. Das, Cengage Learning

On successful completion of this course, the students:

- Should be able design retaining wall subjected to various loads with the knowledge of earth pressure theories.
- Should be able to design sheet pile wall with different methods.
- Should get familiarized with different construction practices for excavation with advantages and disadvantages of each method.
- Should be able to determine the safety analysis for slopes with different methods proposed in the syllabus.
- Should get introduced with the commercial softwares for analyzing the stability of slopes and retaining walls.

Geotechnical Design. Subsurface site evaluation; integrated design of retaining walls, foundations, pavements, and materials for airports, highways, dams, or other facilities.
Prerequisite:
Reference books:

- Analysis and Design of Substructures: Limit State Design by Swami Saran

Upon completion of the course, the student would be:

- Well acquainted with the various investigation specifications as per the infrastructure to be build on the proposed site.
- knowing about the properties of materials required for the constructing a desired infrastructure
- familiar with design concepts of various foundation systems
- familiar with design of transportation facilities

Decision and Risk Analysis. Development of modern statistical decision theory and risk analysis, and application of these concepts in civil engineering design and decision making; Bayesian statistical decision theory, decision tree, utility concepts, and multi-objective decision problems; modeling and analysis of uncertainties, practical risk evaluation, and formulation of risk-based design criteria, risk benefit trade-offs, and optimal decisions.
Prerequisite:

Sustainable Design Engineering & Technology. Quantitative sustainable design (QSD) and how to navigate engineering decision-making. Economic (life cycle costing, techno-economic assessment) and environmental (life cycle assessment: LCA) sustainability assessments, and how to link these tools to design decisions under uncertainty. Design of engineered technologies individually and in teams, with special attention to water infrastructure and bioenergy production. Semester-long design project that includes components from two of the following three CEE sub-disciplines: environmental, hydraulic, geotechnical.
Prerequisite:

Structural Geology. Description, classification, and origin of earth structures. Ways in which the continental crust can deform; link scales of structure from the field, outcrops, hand specimen, thin section by integrating analytical techniques with practical examples. Theoretical and meso to microscale analysis of structures developed through a linked series of lectures and practicals; practical 2D strain analysis; 3D strain concepts; incremental strain, kinematics and polyphase deformations; fold construction and classes; fault evolution and

section balancing; fault rock microstructures; fault and fold mechanics, current concepts in plate tectonics, cross-section construction techniques, structural interpretation of seismic data, structural styles in different tectonic settings (thrust and fold belts, rifts, strike and slip, gravity tectonics, inversion), structural geology of reservoir units.
Prerequisite:
Reference books:

- Ghosh, S.K., Structural Geology: Fundamentals and Modern Developments, Elsevier; First edition

On successful completion of this course the students will be able to:

- Acquire knowledge on the geometry and type of structures present in earth.
- Understand and describe the features formed in rocks when subjected to stress.
- Understand the impact of structural geology to active tectonic settings
- Understand micro and macro scale deformation mechanisms (viz., brittle, ductile).
- Portray 2D and 3D strain analysis for various deformation behaviours.
- Interpret graphs and models used in structural geology to understand and demonstrate poly phase deformations.

Civil Engineering Design-I. Concept of design and its contribution to the quality of life; Civil Engineering Design, the role of geomatics, the environment, and scientific laws in design; Introduction to the design of buildings and Civil Engineering Infrastructure, site appraisal; Risk and vulnerability in design; Health and safety in Civil Engineering Design, environmental impact assessment; Civil Engineering drawing, CAD techniques, introduction to GIS techniques.
Prerequisite:

Civil Engineering Design-II. Innovation and creativity in conceptual design; sustainability; health and safety; investigative procedures. The use of analysis, synthesis and optimization in design; project planning, networks and graphs. Design of embankments, dams; drainage design; route location and alignment design of roads; assessment of natural hazard impacts and environmental impacts.
Prerequisite:

Offshore Engineering. Introduction to offshore structures, codes of practice, offshore project management, deep water, offshore site investigations, geophysical methods; offshore sediment sampling, in-situ testing, geological aspects; development of design stratigraphies.
Prerequisite:

Structural Analysis by Matrix Methods. Analysis of truss and frame structures using flexibility and stiffness methods of matrix analysis; computer applications.
Prerequisite:

Geographic Information Systems and Science. Investigation of geographic information systems (GIS) and science (GIScience) including theory and applications areas. A major portion of the course will be based on use of a current widely-used GIS computer software system. Aspects of geographic data entry and editing, spatial analysis, and map development

and display will be considered. Relationship of GIS to the Global Positioning System (GPS) and satellite generated data will be addressed.
Prerequisite:

Rock Mechanics. Determination of physical properties of rocks, failure criterion, rock mass classification, stress around mine openings, strain and displacement of the rock mass, rock reinforcement and support, subsidence.
Prerequisite:

Reference books:

- Engineering Rock Mechanics: An Introduction to the Principles by J. A. Hudson and J. P. Harrison
- Rock Mechanics: For Underground Mining by Barry H.G. Brady
- Fundamentals of Rock Mechanics, 4th Edition, John Conrad Jaeger, Neville G. W. Cook, Robert Zimmerman

On successful completion of this course the students will be able to:

- Define the properties (viz., physical, mechanical) of rocks and failure criterion of rock mass.
- Use engineering rock mass classification (RMR, Q-system, RQD)
- Analyse the stress distribution insitu and around an opening in underground structures (viz., mine openings, tunnels).
- Determine the relation between strain and displacement components of rockmass.
- Perform field Instrumentation techniques and laboratory studies.
- Understand the fundamentals of ground subsidence.

Modeling and Analysis of Uncertainty. Appreciation and understanding of uncertainties and the conditions under which they occur, within the context of the engineering problem-solving pedagogy of measurements, models, validation, and analysis. Problems and concerns in obtaining measurements; tabular and graphical organization of data to minimize misinformation and maximize information; and development and evaluation of models. Concepts will be supported with computer demonstration. Applications to problems in engineering are emphasized.
Prerequisite:

Environmental Geotechnology. A consideration of technical and scientific aspects of key geo-societal issues. Case studies and analysis of current and historic databases will be used to illustrate topics including, but not limited to, impact of climate change, energy resources, water and soil pollution, and health risks posed by heavy metals and emerging pollutants.
Prerequisite:
Reference books:

- Introduction to Environmental Geotechnology by Hsai – Yang Fang
- CDEEP, IITB video lectures on course CE 488 and CE 641 by Prof. D. N. Singh

Upon successful completion of this course, the student would:

- Have an exposure to interdisciplinary issues pertaining to environment and geotechnical engineering

- Be trained to develop sustainable and environmentally sound solutions for geotechnical problems
- Understand the relevance of various legal aspects involved in addressing environmental consequences associated with geotechnical issues

Ground Improvement Techniques. Introduction, ground modification by vibro-replacement, stone columns, preloading and prefabricated drains, Reinforcedearth structures, Introduction to geotextiles and geomembranes, applications of geotextiles, design methods using geotextiles, geogrids, geonets, geomembranes, geotubes, grouting, deep mixing, PVDs, vacuum consolidation.

Prerequisite:

Reference books:

- Principles and Practice of Ground Improvement by Jie Han
- Ground Improvement Techniques by P. Purushothama Raj

Upon successful completion of this course, the students would:

- gain competence in properly devising alternative solutions to difficult and earth construction problems and in evaluating their effectiveness before, during and after construction.
- understand different approaches to the ground modification.

MODEL CURRICULUM

for

UNDERGRADUATE DEGREE COURSES
IN

ELECTRICAL ENGINEERING

(Engineering & Technology)

[January 2018]

ALL INDIA COUNCIL FOR TECHNICAL EDUCATION
Nelson Mandela Marg, Vasant Kunj, New Delhi 110 070
www.aicte-india.org

All India Council for Technical Education
Model curriculum for
Undergraduate Degree Courses in Engineering & Technology

ELECTRICAL ENGINEERING

CONTENTS

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2	**2**	Detailed 4-YEAR Curriculum Contents
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		BSC 101: Mathematics – I (Calculus and Differential Equations)
		BSC 102: Physics-I (Waves and Optics and Introduction to Quantum Mechanics)
		BSC 103: Mathematics-II (Linear Algebra, Transform Calculus and Numerical Methods)
		BSC 104: Chemistry –I
		BSC 201: Mathematics-III (Probability and Statistics)
		BSC 202: Biology-I
	(ii)	**Engineering Science Courses**
		ESC 101: Problem Solving through Programming (with C)
		ESC 102: Workshop/ Manufacturing Practices
		ESC 103: Engineering Graphics
		ESC 104: Basic Electrical Engineering
		ESC 201: Engineering Mechanics
	(iii)	**Humanities And Social Sciences Including Management**
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		PCC-EE01: Electrical Circuit Analysis
		PCC-EE02: Analog Electronic Circuits
		PCC-EE03: Analog Electronic Circuits Laboratory
		PCC-EE04: Electrical Machines-I
		PCC-EE05: Electrical Machines Laboratory
		PCC-EE06: Electromagnetic Fields
		PCC-EE07: Digital Electronics
		PCC-EE08: Digital Electronics Laboratory
		PCC-EE09: Electrical Machines – II
		PCC-EE10: Electrical Machines Laboratory– II
		PCC-EE11: Power Electronics
		PCC-EE12: Power Electronics Laboratory
		PCC-EE13: Signals and Systems

Sl. No.	**Chapter**	**Title**
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		PCC-EE15: Power Systems – I Laboratory
		PCC-EE16: Control Systems
		PCC-EE17: Control Systems Laboratory
		PCC-EE18: Microprocessors
		PCC-EE19: Microprocessor Laboratory
		PCC-EE20: Power Systems – II
		PCC-EE21: Power Systems-II Laboratory
		PCC-EE22: Measurements and Instrumentation Laboratory
		PCC-EE23 : Electronics Design Laboratory
	(v)	**Professional Elective Courses**
		PEC-EE01: Wind and Solar Energy Systems
		PEC-EE02: Line-Commutated and Active PWM Rectifiers
		PEC-EE03 : Electrical Drives
		PEC-EE04 : Electrical and Hybrid Vehicles
		PEC-EE05: Electrical Machine Design
		PEC-EE06: Power System Protection
		PEC-EE07: HVdc Transmission Systems
		PEC-EE08: Power Quality and FACTS
		PEC-EE09: High Voltage Engineering
		PEC-EE10: Electrical Energy Conservation and Auditing
		PEC-EE11: Industrial Electrical Systems
		PEC-EE12: Power System Dynamics and Control
		PEC-EE13: Digital Control Systems
		PEC-EE14: Digital Signal Processing
		PEC-EE15: Computer Architecture
		PEC-EE16: Electromagnetic waves
		PEC-EE17: Computational Electromagnetics
		PEC-EE18: Control Systems Design
		PEC-EE19: Advanced Electric Drives
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6		Virtual Laboratories for various disciplines

All India Council for Technical Education
Model curriculum for
Undergraduate Degree Courses in Engineering & Technology

ELECTRICAL ENGINEERING

Chapter -1

General, Course structure & Theme
&
Semester-wise credit distribution

Section -1

A. Definition of Credit:

1 Hr. Lecture (L) per week	1 credit
1 Hr. Tutorial (T) per week	1 credit
1 Hr. Practical (P) per week 2 Hours Practical(Lab)/week	0.5 credits 1 credit

B. Range of credits -A range of credits from 150 to 160 for a student to be eligible to get Under Graduate degree in Engineering. A student will be eligible to get Under Graduate degree with Honours or additional Minor Engineering, if he/she completes an additional 20 credits. These could be acquired through MOOCs.

C. Structure of Undergraduate Engineering program :

Sl. No.	Topic	**Credits of the EE Curriculum**
1.	Humanities and Social Sciences including Management	**12**
2.	Basic Sciences	**26**
3.	Engineering Sciences including workshop, drawing, basics of electrical/mechanical/computer etc.	**20**
4.	Professional Core Subjects	**53**
5.	Professional Subjects: Subjects relevant to chosen specialization/branch	**18**
6.	Open Subjects: Electives from other technical and/or emerging subjects	**18**
7.	Project work, seminar and internship in industry or elsewhere	**11**
8.	Mandatory Courses [Environmental Sciences, Induction Program, Indian Constitution, Essence of Indian Traditional Knowledge]	**Non-credit**
	Total	**158**

D. Credit distribution in the First year of Undergraduate Engineering program :

	Lecture	Tutorial	Laboratory/Practical	Total credits
Chemistry-I	3	1	3	5.5
Physics-I	3	1	3	5.5
Mathematics-I	3	1	0	4
Mathematics –II	3	1	0	4
Programming for Problem solving	3	0	4	5
English	2	0	2	3
Engineering Graphics	1	0	4	3
Workshop/ Practical	1	0	4	3
Basic Electrical Engg.	3	1	2	5

E. List of Basic Science and Engineering Science Courses that may be taken in 2nd year:

	Lecture	Tutorial	Laboratory/Practical	Total credits
Mathematics-III	3	1	0	4
Biology-I	2	1	0	3
Engineering Mechanics	3	1	0	4

F. Course code and definition:

Course code	Definitions
BSC	Basic Science Courses
ESC	Engineering Science Courses
HSMC	Humanities and Social Sciences including Management courses
PCC-EE	Professional core courses
PEC-EE	Professional Elective courses
OEC-EE	Open Elective courses
LC	Laboratory course
MC	Mandatory courses
PROJ-EE	Project

Section 2:

BASIC SCIENCE COURSES

Sr. No.	Course Code	Course Title	Hrs. /Week L: T: P	Credits	Preferred Semester
1	BSC 101	Mathematics – I (Calculus and Differential Equations)	3:1:0	4	I
2	BSC 102	Physics (Waves and Optics, and Introduction to Quantum Mechanics)	3:1:3	5.5	I
3	BSC 103	Mathematics – II (Linear Algebra, Transform Calculus and Numerical Methods)	3:1:0	4	II
4	BSC 104	Chemistry – I	3:1:3	5.5	II
5	BSC 201	Mathematics – III (Probability and Statistics)	3:1:0	4	IV
6	BSC 202	Biology – I	2:1:0	3	IV
		Total		26	

ENGINEERING SCIENCE COURSES

Sr. No.	Course Code	Course Title	Hrs. /Week L: T: P	Credits	Preferred Semester
1	ESC 101	Programming for Problem Solving	3:0:4	5	II
2	ESC 102	Workshop/Manufacturing Practices	1:0:4	3	II
4	ESC 103	Engineering Graphics	1:0:4	3	I
5	ESC 104	Basic Electrical Engineering	3:1:2	5	I
6	ESC 201	Engineering Mechanics	3:1:0	4	III
		Total		20	

HUMANITIES & SOCIAL SCIENCES INCLUDING MANAGEMENT

Sr. No.	Course Code	Course Title	Hrs. /Week L: T: P	Credits	Preferred Semester
1	HSMC 101	English	2:0:2	3	II
2	HSMC 301	To be selected by Individual Institutions	3:0:0	3	V
3	HSMC 302		3:0:0	3	VI
4	HSMC 401		3:0:0	3	VII
		Total		12	

MANDATORY COURSES

Sr. No.	Course Code	Course Title	Credits	Preferred Semesters
1	MC	[Environmental Sciences, Induction Program, NSS/NCC]	Nil	III, IV
		Total		0

PROFESSIONAL CORE COURSES [ELECTRICAL ENGINEERING]

Sr. No.	Course Code	Course Title	Hrs. /Week L: T: P	Credits	Preferred Semester
1	PCC-EE01	Electrical Circuit Analysis	3:1:0	4	III
2	PCC-EE02	Analog Electronics	3:0:0	3	III
3	PCC-EE03	Analog Electronics Laboratory	0:0:2	1	III
4	PCC-EE04	Electrical Machines – I	3:0:0	3	III
5	PCC-EE05	Electrical Machines Laboratory - I	0:0:2	1	III
6	PCC-EE06	Electromagnetic Fields	3:1:0	4	III
7	PCC-EE07	Digital Electronics	3:0:0	3	IV
8	PCC-EE08	Digital Electronics Laboratory	0:0:2	1	IV
9	PCC-EE09	Electrical Machines – II	3:0:0	3	IV
10	PCC-EE10	Electrical Machines Laboratory - II	0:0:2	1	IV
11	PCC-EE11	Power Electronics	3:0:0	3	IV
12	PCC-EE12	Power Electronics Laboratory	0:0:2	1	IV
13	PCC-EE13	Signals and Systems	2:1:0	3	IV
14	PCC-EE14	Power Systems -I	3:0:0	3	V
15	PCC-EE15	Power Systems Laboratory -I	0:0:2	1	V
16	PCC-EE16	Control Systems	3:0:0	3	V
17	PCC-EE17	Control Systems Laboratory	0:0:2	1	V
18	PCC-EE18	Microprocessors	3:0:0	3	V
19	PCC-EE19	Microprocessors Laboratory	0:0:2	1	V
20	PCC-EE20	Power Systems - II	3:0:0	3	VI
21	PCC-EE21	Power Systems Laboratory - II	0:0:2	1	VI
22	PCC-EE22	Measurements and Instrumentation Lab	2:0:2	3	VI
23	PCC-EE23	Electronic Design Laboratory	1:0:4	3	VI
		Total		53	

PROFESSIONAL ELECTIVE COURSES [ELECTRICAL ENGINEERING]

Sr. No.	Course Code	Course Title	Hrs. /Week L: T: P	Credits	Preferred Semester
1	PEC-EE01	Wind and Solar Energy Systems	3:0:0	3	VII onwards
2	PEC-EE02	Line Commutated and Active Rectifiers	3:0:0	3	VI onwards
3	PEC-EE03	Electrical Drives	3:0:0	3	VI onwards
4	PEC-EE04	Electrical and Hybrid Vehicles	3:0:0	3	VII onwards
5	PEC-EE05	Electrical Machine Design	3:0:0	3	V onwards
6	PEC-EE06	Power System Protection	3:0:0	3	VII onwards
7	PEC-EE07	HVDC Transmission Systems	3:0:0	3	VII onwards
8	PEC-EE08	Power Quality and FACTS	3:0:0	3	VII onwards
9	PEC-EE09	High Voltage Engineering	3:0:0	3	VI onwards
10	PEC-EE10	Electrical Energy Conservation and Auditing	3:0:0	3	VI onwards
11	PEC-EE11	Industrial Electrical Systems	3:0:0	3	VI onwards
12	PEC-EE12	Power System Dynamics and Control	3:0:0	3	VII onwards
13	PEC-EE13	Digital Control Systems	3:0:0	3	VI onwards
14	PEC-EE14	Digital Signal Processing	3:0:0	3	VI onwards
15	PEC-EE15	Computer Architecture	3:0:0	3	VI onwards
16	PEC-EE16	Electromagnetic Waves	3:0:0	3	VI onwards
17	PEC-EE17	Computational Electromagnetics	3:0:0	3	VI onwards
18	PEC-EE18	Control Systems Design	3:0:0	3	VI onwards
19	PEC-EE19	Advanced Electric Drives	3:0:0	3	VIII

OPEN ELECTIVE COURSES [ELECTRICAL ENGINEERING]

This is only an indicative list (Not Exhaustive)

Sl. No	Code No.	Subject	Credits
01	OEC-EE01	Electronic Devices	3
02	OEC-EE02	Data Structures and Algorithms	3
03	OEC-EE03	Analog and Digital Communication	3
04	OEC-EE04	Computer Networks	3
05	OEC-EE05	Embedded Systems	3
06	OEC-EE06	VLSI circuits	3
07	OEC-EE07	Image Processing	3
08	OEC-EE08	Wavelet Transforms	3
09	OEC-EE09	Power Plant Engineering	3
10	OEC-EE10	Thermal and Fluid Engineering	3
11	OEC-EE11	Strength of Materials	3
12	OEC-EE12	Fluid Machinery	3
13	OEC-EE13	Automobile Engineering	3
14	OEC-EE14	Electrical Materials	3
15	OEC-EE15	Modern Manufacturing Processes	3
16	OEC-EE16	Internet of Things	3
17	OEC-EE17	Big Data Analysis	3

Section 3:

4 year Curriculum structure
Undergraduate Degree in Engineering & Technology

Branch / Course: Electrical Engineering
Total credits (4 year course)158

I. **Induction Program**(Please refer **Appendix-A** for guidelines. Details of Induction program also available in the curriculum of Mandatory courses.)

Induction program (mandatory)	**3 weeks duration** (Please refer Appendix-A for guidelines & also details available in the curriculum of Mandatory courses)
Induction program for students to be offered right at the start of the first year.	• Physical activity • Creative Arts • Universal Human Values • Literary • Proficiency Modules • Lectures by Eminent People • Visits to local Areas • Familiarization to Dept./Branch & Innovations

II. Semester-wise structure of curriculum

[L= Lecture, T = Tutorials, P = Practicals& C = Credits]

Semester I (First year]
Branch/Course : Electrical Engineering

Sl. No.	Course Code	Course Title	Hours per week			Total contact hours	Credits
			Lecture	Tutorial	Practical		
1	BSC 101	Mathematics – I (Calculus and Differential Equations)	3	1	0	4	4
2	BSC 102	Physics – I (Waves and Optics and Introduction to Quantum Mechanics)	3	1	3	7	5.5
3	HSMC 101	English	2	0	2	4	3
4	ESC 101	Programming for Problem Solving	3	0	4	7	5

		TOTAL CREDITS	17.5

Semester II(First year]
Branch/Course : Electrical Engineering

Sl. No.	Course Code	Course Title	Hours per week			Total contact hours	Credits
			Lecture	Tutorial	Practical		
1	BSC 103	Mathematics – II (Linear Algebra, Transform Calculus and Numerical Methods)	3	1	0	4	4
2	BSC 104	Chemistry – I	3	1	3	7	5.5
3	ESC 102	Workshop/Manufacturing Practices	1	0	4	5	3
4	ESC 103	Engineering Graphics	1	0	4	5	3
5	ESC 104	Basic Electrical Engineering	3	1	2	6	5
						TOTAL CREDITS	**20.5**

Semester III [Second year]
Branch/Course : Electrical Engineering

Sl. No	Course Code	Course Title	Hours per week			Total contact hours	Credits
			Lecture	Tutorial	Practical		
1	PCC-EE01	Electrical Circuit Analysis	3	1	0	4	4
2	PCC-EE02	Analog Electronics	3	0	0	3	3
3	PCC-EE03	Analog Electronics Laboratory	0	0	2	2	1
4	PCC-EE04	Electrical Machines – I	3	0	0	3	3
5	PCC-EE05	Electrical Machines Laboratory - I	0	0	2	2	1
6	PCC-EE06	Electromagnetic Fields	3	1	0	4	4
7	ESC 201	Engineering Mechanics	3	1	0	4	4
						TOTAL CREDITS	**20**
8	MC	Slot for MC					0

Semester IV [Second year]
Branch/Course : Electrical Engineering

Sl. No.	Course Code	Course Title	Hours per week			Total contact hours	Credits
			Lecture	Tutorial	Practical		
1	PCC-EE07	Digital Electronics	3	0	0	3	3
2	PCC-EE08	Digital Electronics Laboratory	0	0	2	2	1
3	PCC-EE09	Electrical Machines – II	3	0	0	3	3
4	PCC-EE10	Electrical Machines Laboratory - II	0	0	2	2	1
5	PCC-EE11	Power Electronics	3	0	0	3	3
6	PCC-EE12	Power Electronics Laboratory	0	0	2	2	1
7	PCC-EE13	Signals and Systems	2	1	0	3	3
8	BSC 201	Mathematics – III (Probability and Statistics)	3	1	0	4	4
9	BSC 202	Biology-I	2	1	0	3	3
		TOTAL CREDITS					**22**
10	MC	Slot for MC					0

Semester V [Third year]
Branch/Course : Electrical Engineering

Sl. No.	Course Code	Course Title	Hours per week			Total contact hours	Credits
			Lecture	Tutorial	Practical		
1	PCC-EE14	Power Systems – I (Apparatus and Modelling)	3	0	0	3	3
2	PCC-EE15	Power Systems Laboratory - I	0	0	2	2	1
3	PCC-EE16	Control Systems	3	0	0	3	3
4	PCC-EE17	Control Systems Laboratory	0	0	2	2	1
5	PCC-EE18	Microprocessors	3	0	0	3	3
6	PCC-EE19	Microprocessors Laboratory	0	0	2	2	1
7	PEC-EE01	Program Elective - 1	3	0	0	3	3
8	OEC-EE01	OE-1	3	0	0	3	3
9	HSMC 301	Slot for HS	3	0	0	3	3
		TOTAL CREDITS					**21**

Semester VI [Third year]
Branch/Course : Electrical Engineering

Sl. No.	Course Code	Course Title	Hours per week			Total contact hours	Credits
			Lecture	Tutorial	Practical		
1	PCC-EE20	Power Systems – II (Operation and Control)	3	0	0	3	3
2	PCC-EE21	Power Systems Laboratory - II	0	0	2	2	1
3	PCC-EE22	Measurements and Instrumentation Laboratory	2	0	2	3	3
4	PCC-EE23	Electronics Design Laboratory	1	0	4	5	3
5	PEC-EE02	Program Elective - 2	3	0	0	3	3
6	PEC-EE03	Program Elective - 3	3	0	0	3	3
7	OEC-EE02	OE-2	3	0	0	3	3
8	HSMC 302	Slot for HS	3	0	0	3	3
		TOTAL CREDITS					**22**
	PROJ-EE	Summer Internship	During Summer Vacations / Non-credit				

Semester VII [Fourth year]
Branch/Course : Electrical Engineering

Sl. No.	Course Code	Course Title	Hours per week			Total contact hours	Credits
			Lecture	Tutorial	Practical		
1	PEC-EE04	Program Elective -4	3	0	0	3	3
2	PEC-EE05	Program Elective -5	3	0	0	3	3
3	OEC-EE03	OE-3	3	0	0	3	3
4	OEC-EE04	OE-4	3	0	0	3	3
5	PROJ-EE01	Project Stage-I	0	0	6	6	3
6	HSMC 401	Slot for HS	3	0	0	3	3
		TOTAL CREDITS					**18**

Semester VIII [Fourth year]
Branch/Course : Electrical Engineering

Sl. No.	Course Code	Course Title	Hours per week			Total contact hours	Credits
			Lecture	Tutorial	Practical		
1	PEC-EE06	Program Elective -6	3	0	0	3	3
2	OEC-EE05	OE-5	3	0	0	3	3
3	OEC-EE06	OE-6	3	0	0	3	3
4	PROJ-EE02	Project Stage-II	0	0	16	16	8
		TOTAL CREDITS					**17**

TOTAL CREDITS – 158

CHAPTER 2

DETAILED 4-YEAR CURRICULUM CONTENTS

Undergraduate Degree in Engineering & Technology

Branch/Course: ELECTRICAL ENGINEERING

BASIC SCIENCE COURSES

BSC 101	**Mathematics – I** **(Calculus and Differential Equations)**	**3L:1T:0P**	**4 credits**

Contents

Module 1: Calculus (8 hours)

Evolutes and involutes; Evaluation of definite and improper integrals; Beta and Gamma functions and their properties; Applications of definite integrals to evaluate surface areas and volumes of revolutions. Rolle's theorem, Mean value theorems, Taylor's and Maclaurin theorems with remainders; Indeterminate forms and L'Hospital's rule; Maxima and minima.

Module 2: Sequences and Series (7 hours)

Convergence of sequence and series, tests for convergence, power series, Taylor's series. Series for exponential, trigonometric and logarithmic functions; Fourier series: Half range sine and cosine series, Parseval's theorem.

Module 3: Multivariable Calculus: Differentiation (6 hours)

Limit, continuity and partial derivatives, directional derivatives, total derivative; Tangent plane and normal line; Maxima, minima and saddle points; Method of Lagrange multipliers; Gradient, curl and divergence.

Module 4: Multivariable Calculus: Integration (7 hours)

Multiple Integration: double and triple integrals (Cartesian and polar), change of order of integration in double integrals, Change of variables (Cartesian to polar), Applications: areas and volumes by (double integration) Center of mass and Gravity (constant and variable densities). Theorems of Green, Gauss and Stokes, orthogonal curvilinear coordinates, Simple applications involving cubes, sphere and rectangular parallelepipeds.

Module 5: First Order Ordinary Differential Equations (3 hours)

Exact, linear and Bernoulli's equations, Euler's equations, Equations not of first degree: equations solvable for p, equations solvable for y, equations solvable for x and Clairaut's type.

Module 6: Ordinary Differential Equations of Higher Order (6 hours)

Second order linear differential equations with variable coefficients, method of variation of parameters, Cauchy-Euler equation; Power series solutions; Legendre polynomials, Bessel functions of the first kind and their properties.

Module 7: Partial Differential Equations: First Order (3 hours)

First order partial differential equations, solutions of first order linear and non-linear PDEs.

Text / References:

1. G.B. Thomas and R.L. Finney, "Calculus and Analytic geometry", Pearson, 2002.
2. T. Veerarajan, "Engineering Mathematics", McGraw-Hill, New Delhi, 2008.
3. B. V. Ramana, "Higher Engineering Mathematics", McGraw Hill, New Delhi, 2010.
4. N.P. Bali and M. Goyal, "A text book of Engineering Mathematics", Laxmi Publications, 2010.
5. B.S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, 2000.
6. E. Kreyszig, "Advanced Engineering Mathematics", John Wiley & Sons, 2006.
7. W. E. Boyce and R. C. DiPrima, "Elementary Differential Equations and Boundary Value Problems", Wiley India, 2009.
8. S. L. Ross, "Differential Equations", Wiley India, 1984.
9. E. A. Coddington, "An Introduction to Ordinary Differential Equations", Prentice Hall India, 1995.
10. E. L. Ince, "Ordinary Differential Equations", Dover Publications, 1958.
11. G.F. Simmons and S.G. Krantz, "Differential Equations", McGraw Hill, 2007.

BSC 102	**Physics-I (Waves and Optics and Introduction to Quantum Mechanics)**	**3L:1T:3P**	**5.5 credits**

Module 1: Waves (3 hours)

Mechanical and electrical simple harmonic oscillators, damped harmonic oscillator, forced mechanical and electrical oscillators, impedance, steady state motion of forced damped harmonic oscillator

Module 2: Non-dispersive transverse and longitudinal waves (4 hours)

Transverse wave on a string, the wave equation on a string, Harmonic waves, reflection and transmission of waves at a boundary, impedance matching, standing waves and their Eigen frequencies, longitudinal waves and the wave equation for them, acoustics waves

Module 3: Light and Optics (3 hours)

Light as an electromagnetic wave and Fresnel equations, reflectance and transmittance, Brewster's angle, total internal reflection, and evanescent wave. Mirrors and lenses and optical instruments based on them

Module 4: Wave Optics (5 hours)

Huygens' principle, superposition of waves and interference of light by wavefront splitting and amplitude splitting; Young's double slit experiment, Newton's rings, Michelson interferometer, Mach Zehnder interferometer. Farunhofer diffraction from a single slit and a circular aperture, the Rayleigh criterion for limit of resolution and its application to vision; Diffraction gratings and their resolving power

Module 5: Lasers (5 hours)

Einstein's theory of matter radiation interaction and A and B coefficients; amplification of light by population inversion, different types of lasers: gas lasers (He-Ne, CO_2), solid-state lasers (ruby, Neodymium), dye lasers; Properties of laser beams: mono-chromaticity

Module 6: Introduction to Quantum Mechanics (5 hours)

Wave nature of Particles, Time-dependent and time-independent Schrodinger equation for wave function, Born interpretation, probability current, Expectation values, Free-particle wave function and wave-packets, Uncertainty principle.

Module 7: Solution of Wave Equation(6 hours)

Solution of stationary-state Schrodinger equation for one dimensional problems–particle in a box, particle in attractive delta-function potential, square-well potential, linear harmonic oscillator. Scattering from a potential barrier and tunneling; related examples like alpha-decay, field-ionization and scanning tunneling microscope, tunneling in semiconductor structures. Three-dimensional problems: particle in three dimensional box and related examples.

Module 8: Introduction to Solids and Semiconductors.(9 hours)

Free electron theory of metals, Fermi level, density of states in 1, 2 and 3 dimensions, Bloch's theorem for particles in a periodic potential, Kronig-Penney model and origin of energy bands.

Types of electronic materials: metals, semiconductors, and insulators. Intrinsic and extrinsic semiconductors, Dependence of Fermi level on carrier-concentration and temperature (equilibrium carrier statistics), Carrier generation and recombination, Carrier transport: diffusion and drift, p -n junction.

Text / References:

1. I. G. Main, "Vibrations and waves in physics", Cambridge University Press, 1993.
2. H. J. Pain, "The physics of vibrations and waves", Wiley, 2006.
3. E. Hecht, "Optics", Pearson Education, 2008.
4. A. Ghatak, "Optics", McGraw Hill Education, 2012.
5. O. Svelto, "Principles of Lasers", Springer Science & Business Media, 2010.
6. D. J. Griffiths, "Quantum mechanics", Pearson Education, 2014.
7. R. Robinett, "Quantum Mechanics", OUP Oxford, 2006.
8. D. McQuarrie, "Quantum Chemistry", University Science Books, 2007.
9. D. A. Neamen, "Semiconductor Physics and Devices", Times Mirror High Education Group, Chicago, 1997.
10. E.S. Yang, "Microelectronic Devices", McGraw Hill, Singapore, 1988.
11. B.G. Streetman, "Solid State Electronic Devices", Prentice Hall of India, 1995.

BSC 103	Mathematics-II (Linear Algebra, Transform Calculus and Numerical Methods)	3L:1T:0P	4 credits

Module 1: Matrices (10 hours)

Algebra of matrices, Inverse and rank of a matrix, rank-nullity theorem; System of linear equations; Symmetric, skew-symmetric and orthogonal matrices; Determinants; Eigenvalues and eigenvectors; Diagonalization of matrices; Cayley-Hamilton Theorem, Orthogonal transformation and quadratic to canonical forms.

Module 2: Numerical Methods-I (10 hours)

Solution of polynomial and transcendental equations – Bisection method, Newton-Raphson method and Regula-Falsi method. Finite differences, Interpolation using Newton's forward and backward difference formulae. Central difference interpolation: Gauss's forward and backward formulae. Numerical integration: Trapezoidal rule and Simpson's 1/3rd and 3/8 rules.

Module 3: Numerical Methods-II (10 hours)

Ordinary differential equations: Taylor's series, Euler and modified Euler's methods. Runge-Kutta method of fourth order for solving first and second order equations. Milne's and Adam's predicator-corrector methods. Partial differential equations: Finite difference solution two dimensional Laplace equation and Poisson equation, Implicit and explicit methods for one dimensional heat equation (Bender-Schmidt and Crank-Nicholson methods), Finite difference explicit method for wave equation.

Module 4: Transform Calculus (10 hours)

Laplace Transform, Properties of Laplace Transform, Laplace transform of periodic functions. Finding inverse Laplace transform by different methods, convolution theorem. Evaluation of integrals by Laplace transform, solving ODEs and PDEs by Laplace Transform method. Fourier transforms.

Text / References:

1. D. Poole, "Linear Algebra: A Modern Introduction", Brooks/Cole, 2005.
2. N.P. Bali and M. Goyal, "A text book of Engineering Mathematics", Laxmi Publications, 2008.
3. B.S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, 2010.
4. V. Krishnamurthy, V. P. Mainra and J. L. Arora, "An introduction to Linear Algebra", Affiliated East-West press, 2005.

BSC 104	Chemistry -I	3L:1T:3P	5.5 credits

Contents

Module 1: Atomic and molecular structure (12 hours)

Schrodinger equation. Particle in a box solutions and their applications for conjugated molecules and nanoparticles. Forms of the hydrogen atom wave functions and the plots of these functions to explore their spatial variations. Molecular orbitals of diatomic molecules and plots of the multi-centre orbitals. Equations for atomic and molecular orbitals. Energy level diagrams of diatomics. Pi-molecular orbitals of butadiene and benzene and aromaticity. Crystal field theory and the energy level diagrams for transition metal ions and their magnetic properties. Band structure of solids and the role of doping on band structures.

Module 2: Spectroscopic techniques and applications (8 hours)

Principles of spectroscopy and selection rules. Electronic spectroscopy. Fluorescence and its applications in medicine. Vibrational and rotational spectroscopy of diatomic molecules. Applications. Nuclear magnetic resonance and magnetic resonance imaging, surface characterization techniques. Diffraction and scattering.

Module 3: Intermolecular forces and potential energy surfaces (4 hours)

Ionic, dipolar and van Der Waals interactions. Equations of state of real gases and critical phenomena. Potential energy surfaces of H_3, H_2F and HCN and trajectories on these surfaces.

Module 4: Use of free energy in chemical equilibria (6 hours)

Thermodynamic functions: energy, entropy and free energy. Estimations of entropy and free energies. Free energy and emf. Cell potentials, the Nernst equation and applications. Acid base, oxidation reduction and solubility equilibria. Water chemistry. Corrosion. Use of free energy considerations in metallurgy through Ellingham diagrams.

Module 5: Periodic properties (4 hours)

Effective nuclear charge, penetration of orbitals, variations of s, p, d and f orbital energies of atoms in the periodic table, electronic configurations, atomic and ionic sizes, ionization energies, electron affinity and electronegativity, polarizability, oxidation states, coordination numbers and geometries, hard soft acids and bases, molecular geometries

Module 6: Stereochemistry (4 hours)

Representations of 3 dimensional structures, structural isomers and stereoisomers, configurations and symmetry and chirality, enantiomers, diastereomers, optical activity, absolute configurations and conformational analysis. Isomerism in transitional metal compounds.

Module 7: Organic reactions and synthesis of a drug molecule (4 hours)

Introduction to reactions involving substitution, addition, elimination, oxidation, reduction, cyclization and ring openings. Synthesis of a commonly used drug molecule.

Text / References:

1. B. H. Mahan, "University chemistry", Addison-Wesley Publishing Company, 1975.
2. M. J. Sienko and R. A. Plane, "Chemistry: Principles and Applications", McGraw Hill International, 1974.
3. C. N. Banwell, "Fundamentals of Molecular Spectroscopy", McGraw Hill Education, 1994.
4. B. L. Tembe, Kamaluddin and M. S. Krishnan, "Engineering Chemistry" (NPTEL).
5. K. P. C. Volhardt and N. E. Schore, "Organic Chemistry: Structure and Function" Freeman, 2010.

Course Outcomes

The concepts developed in this course will aid in quantification of several concepts in chemistry that have been introduced at the 10+2 levels in schools. Technology is being increasingly based on the electronic, atomic and molecular level modifications.

Quantum theory is more than 100 years old and to understand phenomena at nanometer levels, one has to base the description of all chemical processes at molecular levels. The course will enable the student to:

- Analyse microscopic chemistry in terms of atomic and molecular orbitals and intermolecular forces.
- Rationalise bulk properties and processes using thermodynamic considerations.
- Distinguish the ranges of the electromagnetic spectrum used for exciting different molecular energy levels in various spectroscopic techniques
- Rationalise periodic properties such as ionization potential, electronegativity, oxidation states and electronegativity.
- List major chemical reactions that are used in the synthesis of molecules.

Chemistry Laboratory (0:0:3 - 1.5 credits)

Choice of 10-12 experiments from the following

1. Determination of surface tension and viscosity
2. Thin layer chromatography
3. Ion exchange column for removal of hardness of water
4. Determination of chloride content of water
5. Colligative properties using freezing point depression
6. Determination of the rate constant of a reaction
7. Determination of cell constant and conductance of solutions
8. Potentiometry - determination of redox potentials and emfs.
9. Synthesis of a polymer/drug
10. Saponification/acid value of an oil
11. Chemical analysis of a salt
12. Lattice structures and packing of spheres
13. Models of potential energy surfaces
14. Chemical oscillations- Iodine clock reaction
15. Determination of the partition coefficient of a substance between two immiscible liquids
16. Adsorption of acetic acid by charcoal

17. Use of the capillary viscosimeters to the demonstrate of the isoelectric point as the pH of minimum viscosity for gelatin sols and/or coagulation of the white part of egg

Laboratory Outcomes

- The chemistry laboratory course will consist of experiments illustrating the principles of chemistry relevant to the study of science and engineering. The students will learn to:
- Estimate rate constants of reactions from concentration of reactants/products as a function of time
- Measure molecular/system properties such as surface tension, viscosity, conductance of solutions, redox potentials, chloride content of water, etc
- Synthesize a small drug molecule and analyse a salt sample

BSC 201	Mathematics-III (Probability and Statistics)	3L:1T:0P	4 credits

Module 1: Basic Probability (12 hours)

Probability spaces, conditional probability, independence; Discrete random variables, Independent random variables, the multinomial distribution, Poisson approximation to the binomial distribution, infinite sequences of Bernoulli trials, sums of independent random variables; Expectation of Discrete Random Variables, Moments, Variance of a sum, Correlation coefficient, Chebyshev's Inequality.

Module 2: Continuous Probability Distributions (4 hours)

Continuous random variables and their properties, distribution functions and densities, normal, exponential and gamma densities.

Module 3: Bivariate Distributions (4 hours)

Bivariate distributions and their properties, distribution of sums and quotients, conditional densities, Bayes' rule.

Module 4: Basic Statistics (8 hours)

Measures of Central tendency: Moments, skewness and Kurtosis - Probability distributions: Binomial, Poisson and Normal - evaluation of statistical parameters for these three distributions, Correlation and regression – Rank correlation.

Module 5: Applied Statistics (8 hours)

Curve fitting by the method of least squares- fitting of straight lines, second degree parabolas and more general curves. Test of significance: Large sample test for single proportion, difference of proportions, single mean, difference of means, and difference of standard deviations.

Module 6: Small samples (4 hours)

Test for single mean, difference of means and correlation coefficients, test for ratio of variances - Chi-square test for goodness of fit and independence of attributes.

Text / References:

1. E. Kreyszig, "Advanced Engineering Mathematics", John Wiley & Sons, 2006.
2. P. G. Hoel, S. C. Port and C. J. Stone, "Introduction to Probability Theory", Universal Book Stall, 2003.
3. S. Ross, "A First Course in Probability", Pearson Education India, 2002.
4. W. Feller, "An Introduction to Probability Theory and its Applications", Vol. 1, Wiley, 1968.
5. N.P. Bali and M. Goyal, "A text book of Engineering Mathematics", Laxmi Publications, 2010.
6. B.S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, 2000.
7. T. Veerarajan, "Engineering Mathematics", Tata McGraw-Hill, New Delhi, 2010.

BSC 202	Biology-I	2L:1T:0P	3 credits

Module 1: Introduction (2 hours)

Purpose: To convey that Biology is as important a scientific discipline as Mathematics, Physics and Chemistry. Bring out the fundamental differences between science and engineering by drawing a comparison between eye and camera, Bird flying and aircraft. Mention the most exciting aspect of biology as an independent scientific discipline. Why we need to study biology? Discuss how biological observations of 18th Century that lead to major discoveries. Examples from Brownian motion and the origin of thermodynamics by referring to the original observation of Robert Brown and Julius Mayor. These examples will highlight the fundamental importance of observations in any scientific inquiry.

Module 2: Classification (3 hours)

Purpose: To convey that classification *per se* is not what biology is all about. The underlying criterion, such as morphological, biochemical or ecological be highlighted. Hierarchy of life forms at phenomenological level. A common thread weaves this hierarchy Classification. Discuss classification based on (a) cellularity- Unicellular or multicellular (b) ultrastructure- prokaryotes or eucaryotes. (c) energy and Carbon utilization -Autotrophs, heterotrophs, lithotropes (d) Ammonia excretion – aminotelic, uricotelic, ureotelic (e) Habitata- acquatic or terrestrial (e) Molecular taxonomy- three major kingdoms of life. A given organism can come under different category based on classification. Model organisms for the study of biology come from different groups. E.coli, S.cerevisiae, D. Melanogaster, C. elegance, A. Thaliana, M. musculus

Module 3: Genetics (4 hours)

Purpose: To convey that "Genetics is to biology what Newton's laws are to Physical Sciences". Mendel's laws, Concept of segregation and independent assortment. Concept of allele. Gene mapping, Gene interaction, Epistasis. Meiosis and Mitosis be taught as a part of genetics. Emphasis to be give not to the mechanics of cell division nor the phases but how genetic material passes from parent to offspring. Concepts of recessiveness and dominance. Concept of mapping of phenotype to genes. Discuss about the single gene disorders in humans. Discuss the concept of complementation using human genetics.

Module 4: Biomolecules (4 hours)

Purpose: To convey that all forms of life has the same building blocks and yet the manifestations are as diverse as one can imagine. Molecules of life. In this context discuss monomeric units and polymeric structures. Discuss about sugars, starch and cellulose. Amino acids and proteins. Nucleotides and DNA/RNA. Two carbon units and lipids.

Module 5: Enzymes (4 Hours)

Purpose: To convey that without catalysis life would not have existed on earth.

Enzymology: How to monitor enzyme catalysed reactions. How does an enzyme catalyse reactions? Enzyme classification. Mechanism of enzyme action. Discuss at least two examples. Enzyme kinetics and kinetic parameters. Why should we know these parameters to understand biology? RNA catalysis.

Module 6: Information Transfer (4 hours)

Purpose: The molecular basis of coding and decoding genetic information is universal. Molecular basis of information transfer. DNA as a genetic material. Hierarchy of DNA structure- from single stranded to double helix to nucleosomes. Concept of genetic code. Universality and degeneracy of genetic code. Define gene in terms of complementation and recombination.

Module 7: Macromolecular analysis (5 hours)

Purpose: To analyse biological processes at the reductionistic level. Proteins- structure and function. Hierarch in protein structure. Primary secondary, tertiary and quaternary structure. Proteins as enzymes, transporters, receptors and structural elements.

Module 8: Metabolism (4 hours)

Purpose: The fundamental principles of energy transactions are the same in physical and biological world. Thermodynamics as applied to biological systems. Exothermic and endothermic versus endergonic and exergonic reactions. Concept of K_{eq} and its relation to standard free energy. Spontaneity. ATP as an energy currency. This should include the breakdown of glucose to $CO_2 + H_2O$ (Glycolysis and Krebs cycle) and synthesis of glucose from CO_2 and H_2O (Photosynthesis). Energy yielding and energy consuming reactions. Concept of Energy charge.

Module 9. Microbiology (3 hours)

Concept of single celled organisms. Concept of species and strains. Identification and classification of microorganisms. Microscopy. Ecological aspects of single celled organisms. Sterilization and media compositions. Growth kinetics.

Text / References:

1. N. A. Campbell, J. B. Reece, L. Urry, M. L. Cain and S. A. Wasserman, “Biology: A global approach”, Pearson Education Ltd, 2014.
2. E. E. Conn, P. K. Stumpf, G. Bruening and R. H. Doi, “Outlines of Biochemistry”, John Wiley and Sons, 2009.
3. D. L. Nelson and M. M. Cox, “Principles of Biochemistry”, W.H. Freeman and Company, 2012.
4. G. S. Stent and R. Calendar, “Molecular Genetics”, Freeman and company, 1978.

5. L. M. Prescott, J. P. Harley and C. A. Klein, "Microbiology", McGraw Hill Higher Education, 2005.

Course Outcomes

After studying the course, the student will be able to:

- Describe how biological observations of 18th Century that lead to major discoveries.
- Convey that classification *per se* is not what biology is all about but highlight the underlying criteria, such as morphological, biochemical and ecological
- Highlight the concepts of recessiveness and dominance during the passage of genetic material from parent to offspring
- Convey that all forms of life have the same building blocks and yet the manifestations are as diverse as one can imagine
- Classify enzymes and distinguish between different mechanisms of enzyme action.
- Identify DNA as a genetic material in the molecular basis of information transfer.
- Analyse biological processes at the reductionistic level
- Apply thermodynamic principles to biological systems.
- Identify and classify microorganisms.

ENGINEERING SCIENCE COURSES

ESC 101	**Problem Solving through Programming (with C)**	**3L:0T:4P**	**5 credits**

Course Outcomes: The course will enable the students.

- To formulate simple algorithms for arithmetic and logical problems.
- To translate the algorithms to programs (in C language).
- To test and execute the programs and correct syntax and logical errors.
- To implement conditional branching, iteration and recursion.
- To decompose a problem into functions and synthesize a complete program using divide and conquer approach.
- To use arrays, pointers and structures to formulate algorithms and programs.
- To apply programming to solve matrix addition and multiplication problems and searching and sorting problems.
- To apply programming to solve simple numerical method problems, namely rot finding of function, differentiation of function and simple integration.

Unit 1: Introduction to Programming (3 hours)
Introduction to the idea of algorithm; Introduction to Programming (Flow chart/pseudocode); the compilation process, object code and executables, Variables (including data types), Mapping of variables to memory locations, Syntax and logical error

Unit 2: Arithmetic expressions, precedence, Conditional Branching and Loops (10 hours)
Writing and evaluation of conditionals and consequent branching, Iteration and loops.

Unit 3: Arrays (6 hours)
Arrays (1-D, 2-D), Character arrays and Strings.

Unit 4: Basic Algorithms (6 hours)
Searching: Linear and Binary, Basic Sorting Algorithms, Finding roots of equations (two algorithms)

Unit 5: Function and Recursion (10 hours)
Functions (including using built in libraries), Parameter passing, Call by value, Passing Arrays to functions, Call by reference. Introduction to Recursion; Base condition, example programs such as Factorial, Fibonacci series, Quick sort, Ackerman function etc.

Unit 6: Structures and Pointers (5 hrs)
Structures, typedef, Array of structures; notional introduction to pointers including self-referential structures.

File handling should be done in laboratory.

Tutorial and Lab combined: (total 4 contact hours per week) (outline of topics)

Tutorial 1: Problem solving using computers: Lab1: Familiarization with programming environment

Tutorial 2: Variable types and type conversions: Lab 2: Simple computational problems using arithmetic expressions

Tutorial 3: Branching and logical expressions: Lab 3: Problems involving if-then-else structures

Tutorial 4: Loops, while and for loops: Lab 4: Iterative problems e.g., sum of series

Tutorial 5: 1D Arrays: searching, sorting: Lab 5: 1D Array manipulation

Tutorial 6: 2D arrays and Strings, memory structure: Lab 6: Matrix problems, String operations

Tutorial 7: Functions, call by value: Lab 7: Simple functions

Tutorial 8 & 9: Numerical methods (Root finding, numerical differentiation, numerical integration): Lab 8 and 9: Numerical methods problems

Tutorial 10: Recursion, structure of recursive calls: Lab 10: Recursive functions

Tutorial 11: Pointers explained Lab 11: Implementing and accessing array of structures

Tutorial 12: File handling: Lab 12: File operations

Text / References:

1. B. Gottfried, “Programming with C”, McGraw-Hill Professional, 1996.
2. E. Balagurusamy, “Programming in ANSI C”, McGraw-Hill Education, 2008.
3. B. W. Kernighan and D. M. Ritchie, “The C Programming Language”, Prentice Hall of India, 1990.

ESC 102	Workshop/ Manufacturing Practices	1L:0T:4P	3 credits

Manufacturing is fundamental to the development of any engineering product. The course on Engineering Workshop Practice is intended to expose engineering students to different types of manufacturing/ fabrication processes, dealing with different materials such as metals, ceramics, plastics, wood, glass etc. While the actual practice of fabrication techniques is given more weightage, some lectures and video clips available on different methods of manufacturing are also included.

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Understanding different manufacturing techniques and their relative advantages/ disadvantages with respect to different applications.
- Selection of a suitable technique for meeting a specific fabrication need.
- Acquire a minimum practical skill with respect to the different manufacturing methods and develop the confidence to design & fabricate small components for their project work and also to participate in various national and international technical competitions.
- Introduction to different manufacturing methods in different fields of engineering.

- Practical exposure to different fabrication techniques.
- Creation of simple components using different materials.
- Exposure to some of the advanced and latest manufacturing techniques being employed in the industry.

Letcures& videos: (10 hours)

1. Manufacturing Methods- casting, forming, machining, joining, advanced manufacturing methods (3 lectures)
2. CNC machining, Additive manufacturing (1 lecture)
3. Fitting operations & power tools (1 lecture)
4. Electrical & Electronics (1 lecture)
5. Carpentry (1 lecture)
6. Plastic moulding, glass cutting (1 lecture)
7. Metal casting (1 lecture)
8. Welding (arc welding & gas welding), brazing (1 lecture)

Workshop Practice: (60 hours)

1. Machine shop - 10 hours
2. Fitting shop - 8 hours
3. Carpentry - 6 hours
4. Electrical & Electronics - 8 hours
5. Welding shop - 8 hours (Arc welding 4 hrs + gas welding 4 hrs)
6. Casting - 8 hours
7. Smithy - 6 hours
8. Plastic moulding&Glass Cutting - 6 hours

Examinations could involve the actual fabrication of simple components, utilizing one or more of the techniques covered above.

ESC 103	**Engineering Graphics**	**1L:0T:4P**	**3 credits**

All phases of manufacturing or construction require the conversion of new ideas and design concepts into the basic line language of graphics. Therefore, there are many areas (civil, mechanical, electrical, architectural and industrial) in which the skills of the CAD technicians play major roles in the design and development of new products or construction. Students prepare for actual work situations through practical training in a new state-of-the-art computer designed CAD laboratory using engineering software.

This course is designed to address:

- to prepare you to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- to prepare you to communicate effectively
- to prepare you to use the techniques, skills, and modern engineering tools necessary for engineering practice

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Introduction to engineering design and its place in society
- Exposure to the visual aspects of engineering design
- Exposure to engineering graphics standards
- Exposure to solid modelling
- Exposure to computer-aided geometric design
- Exposure to creating working drawings
- Exposure to engineering communication

Proposed Syllabus

Traditional Engineering Graphics: Principles of Engineering Graphics; Orthographic Projection; Descriptive Geometry; Drawing Principles; Isometric Projection; Surface Development; Perspective; Reading a Drawing; Sectional Views; Dimensioning & Tolerances; True Length, Angle; intersection, Shortest Distance.

Computer Graphics: Engineering Graphics Software; -Spatial Transformations; Orthographic Projections; Model Viewing; Co-ordinate Systems; Multi-view Projection; Exploded Assembly; Model Viewing; Animation; Spatial Manipulation; Surface Modelling; Solid Modelling

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ESC 104	Basic Electrical Engineering	3L:1T:2P	5 credits

Course Outcomes:
At the end of this course, students will demonstrate the ability

- To understand and analyse basic electric and magnetic circuits.
- To study the working principles of electrical machines and power converters.
- To introduce the components of low-voltage electrical installations.

Module 1 : DC Circuits (8 hours)
Electrical circuit elements (R, L and C), voltage and current sources, Kirchoff current and voltage laws, analysis of simple circuits with dc excitation. Superposition, Thevenin and Norton Theorems. Time-domain analysis of first-order RL and RC circuits.

Module 2: AC Circuits (8 hours)
Representation of sinusoidal waveforms, peak and rms values, phasor representation, real power, reactive power, apparent power, power factor. Analysis of single-phase ac circuits consisting of R, L, C, RL, RC, RLC combinations (series and parallel), resonance. Three-phase balanced circuits, voltage and current relations in star and delta connections.

Module 3: Transformers (6 hours)
Magnetic materials, BH characteristics, ideal and practical transformer, equivalent circuit, losses in transformers, regulation and efficiency. Auto-transformer and three-phase transformer connections.

Module 4: Electrical Machines (8 hours)
Generation of rotating magnetic fields, Construction and working of a three-phase induction motor, Significance of torque-slip characteristic. Loss components and efficiency, starting and speed control of induction motor. Single-phase induction motor. Construction, working, torque-speed characteristic and speed control of separately excited dc motor. Construction and working of synchronous generators.

Module 5: Power Converters (6 hours)
DC-DC buck and boost converters, duty ratio control. Single-phase and three-phase voltage source inverters; sinusoidal modulation.

Module 6: Electrical Installations (6 hours)
Components of LT Switchgear: Switch Fuse Unit (SFU), MCB, ELCB, MCCB, Types of Wires and Cables, Earthing. Types of Batteries, Important Characteristics for Batteries. Elementary calculations for energy consumption, power factor improvement and battery backup.

List of Laboratory Experiments/Demonstrations:

1. Basic safety precautions. Introduction and use of measuring instruments – voltmeter, ammeter, multi-meter, oscilloscope. Real-life resistors, capacitors and inductors.
2. Measuring the steady-state and transient time-response of R-L, R-C, and R-L-C circuits to a step change in voltage (transient may be observed on a storage oscilloscope).

Sinusoidal steady state response of R-L, and R-C circuits – impedance calculation and verification. Observation of phase differences between current and voltage. Resonance in R-L-C circuits.

3. Transformers: Observation of the no-load current waveform on an oscilloscope (non-sinusoidal wave-shape due to B-H curve nonlinearity should be shown along with a discussion about harmonics). Loading of a transformer: measurement of primary and secondary voltages and currents, and power.
4. Three-phase transformers: Star and Delta connections. Voltage and Current relationships (line-line voltage, phase-to-neutral voltage, line and phase currents). Phase-shifts between the primary and secondary side. Cumulative three-phase power in balanced three-phase circuits.
5. Demonstration of cut-out sections of machines: dc machine (commutator-brush arrangement), induction machine (squirrel cage rotor), synchronous machine (field winging - slip ring arrangement) and single-phase induction machine.
6. Torque Speed Characteristic of separately excited dc motor.
7. Synchronous speed of two and four-pole, three-phase induction motors. Direction reversal by change of phase-sequence of connections. Torque-Slip Characteristic of an induction motor. Generator operation of an induction machine driven at super-synchronous speed.
8. Synchronous Machine operating as a generator: stand-alone operation with a load. Control of voltage through field excitation.
9. Demonstration of (a) dc-dc converters (b) dc-ac converters – PWM waveform (c) the use of dc-ac converter for speed control of an induction motor and (d) Components of LT switchgear.

Text / References:

1. D. P. Kothari and I. J. Nagrath, “Basic Electrical Engineering”, Tata McGraw Hill, 2010.
2. D. C. Kulshreshtha, “Basic Electrical Engineering”, McGraw Hill, 2009.
3. L. S. Bobrow, “Fundamentals of Electrical Engineering”, Oxford University Press, 2011.
4. E. Hughes, “Electrical and Electronics Technology”, Pearson, 2010.
5. V. D. Toro, “Electrical Engineering Fundamentals”, Prentice Hall India, 1989.

Laboratory Outcomes: The students are expected to

- Get an exposure to common electrical components and their ratings.
- Make electrical connections by wires of appropriate ratings.
- Understand the usage of common electrical measuring instruments.
- Understand the basic characteristics of transformers and electrical machines.
- Get an exposure to the working of power electronic converters.

ESC 201	Engineering Mechanics	3L:1T:0P	4 credits

Course Outcomes: At the end of this course, students will demonstrate the ability to

- Understand the concepts of co-ordinate systems.
- Analyse the three-dimensional motion.
- Understand the concepts of rigid bodies.
- Analyse the free-body diagrams of different arrangements.
- Analyse torsional motion and bending moment.

Module 1: Introduction to vectors and tensors and co-ordinate systems (5 hours)

Introduction to vectors and tensors and coordinate systems; Vector and tensor algebra; Indical notation; Symmetric and anti-symmetric tensors; Eigenvalues and Principal axes.

Module 2: Three-dimensional Rotation (4 hours)

Three-dimensional rotation: Euler's theorem, Axis-angle formulation and Euler angles; Coordinate transformation of vectors and tensors.

Module 3: Kinematics of Rigid Body (6 hours)

Kinematics of rigid bodies: Dentition and motion of a rigid body; Rigid bodies as coordinate systems; Angular velocity of a rigid body, and its rate of change; Distinction between two- and three-dimensional rotational motion; Integration of angular velocity to find orientation; Motion relative to a rotating rigid body: Five term acceleration formula.

Module 4: Kinetics of Rigid Bodies (5 hours)

Kinetics of rigid bodies: Angular momentum about a point; Inertia tensor: Dentition and computation, Principal moments and axes of inertia, Parallel and perpendicular axes theorems; Mass moment of inertia of symmetrical bodies, cylinder, sphere, cone etc., Area moment of inertia and Polar moment of inertia, Forces and moments; Newton-Euler's laws of rigid body motion.

Module 5: Free Body Diagram (1 hour)

Free body diagrams; Examples on modelling of typical supports and joints and discussion on the kinematic and kinetic constraints that they impose.

Module 6: General Motion (9 hours)

Examples and problems. General planar motions. General 3-D motions. Free precession, Gyroscopes, Rolling coin.

Module 7: Bending Moment (5 hours)

Transverse loading on beams, shear force and bending moment in beams, analysis of cantilevers, simply supported beams and overhanging beams, relationships between loading, shear force and bending moment, shear force and bending moment diagrams.

Module 8: Torsional Motion (2 hours)

Torsion of circular shafts, derivation of torsion equation, stress and deformation in circular and hollow shafts.

Module 9: Friction (3 hours)

Concept of Friction; Laws of Coulomb friction; Angle of Repose; Coefficient of friction.

Text / References:

1. J. L. Meriam and L. G. Kraige, “Engineering Mechanics: Dynamics”, Wiley, 2011.
2. M. F. Beatty, “Principles of Engineering Mechanics”, Springer Science & Business Media, 1986.

HUMANITIES AND SOCIAL SCIENCES INCLUDING MANAGEMENT

HSMC101	English	2L:0T:2P	3 credits

Detailed contents

1. Vocabulary Building

1.1 The concept of Word Formation
1.2 Root words from foreign languages and their use in English
1.3 Acquaintance with prefixes and suffixes from foreign languages in English to form derivatives.
1.4 Synonyms, antonyms, and standard abbreviations.

2. Basic Writing Skills

2.1 Sentence Structures
2.2 Use of phrases and clauses in sentences
2.3 Importance of proper punctuation
2.4 Creating coherence
2.5 Organizing principles of paragraphs in documents
2.6 Techniques for writing precisely

3. Identifying Common Errors in Writing

3.1 Subject-verb agreement
3.2 Noun-pronoun agreement
3.3 Misplaced modifiers
3.4 Articles
3.5 Prepositions
3.6 Redundancies
3.7 Clichés

4. Nature and Style of sensible Writing

4.1 Describing
4.2 Defining
4.3 Classifying
4.4 Providing examples or evidence
4.5 Writing introduction and conclusion

5. Writing Practices

5.1 Comprehension
5.2 Précis Writing
5.3 Essay Writing

6. Oral Communication

(This unit involves interactive practice sessions in Language Lab)

- Listening Comprehension
- Pronunciation, Intonation, Stress and Rhythm
- Common Everyday Situations: Conversations and Dialogues
- Communication at Workplace
- Interviews
- Formal Presentations

Suggested Readings:

(i) *Practical English Usage.* Michael Swan. OUP. 1995.
(ii) *Remedial English Grammar.* F.T. Wood. Macmillan.2007
(iii)*On Writing Well.* William Zinsser. Harper Resource Book. 2001
(iv)*Study Writing.* Liz Hamp-Lyons and Ben Heasly. Cambridge University Press. 2006.
(v) *Communication Skills*. Sanjay Kumar and PushpLata. Oxford University Press. 2011.
(vi)*Exercises in Spoken English.* Parts. I-III. CIEFL, Hyderabad. Oxford University Press

Course Outcomes

The student will acquire basic proficiency in English including reading and listening comprehension, writing and speaking skills.

PROGRAM CORE COURSES

PCC-EE01	**Electrical Circuit Analysis**	**3L:1T:0P**	**4 credits**

Course Outcomes:
At the end of this course, students will demonstrate the ability to

- Apply network theorems for the analysis of electrical circuits.
- Obtain the transient and steady-state response of electrical circuits.
- Analyse circuits in the sinusoidal steady-state (single-phase and three-phase).
- Analyse two port circuit behavior.

Module 1: Network Theorems (10 Hours)

Superposition theorem, Thevenin theorem, Norton theorem, Maximum power transfer theorem, Reciprocity theorem, Compensation theorem. Analysis with dependent current and voltage sources. Node and Mesh Analysis. Concept of duality and dual networks.

Module 2: Solution of First and Second order networks (8 Hours)

Solution of first and second order differential equations for Series and parallel R-L, R-C, R-L-C circuits, initial and final conditions in network elements, forced and free response, time constants, steady state and transient state response.

Module 3: Sinusoidal steady state analysis (8 Hours)

Representation of sine function as rotating phasor, phasor diagrams, impedances and admittances, AC circuit analysis, effective or RMS values, average power and complex power. Three-phase circuits. Mutual coupled circuits, Dot Convention in coupled circuits, Ideal Transformer.

Module 4: Electrical Circuit Analysis Using Laplace Transforms (8 Hours)

Review of Laplace Transform, Analysis of electrical circuits using Laplace Transform for standard inputs, convolution integral, inverse Laplace transform, transformed network with initial conditions. Transfer function representation. Poles and Zeros. Frequency response (magnitude and phase plots), series and parallel resonances

Module 5: Two Port Network and Network Functions (6 Hours)

Two Port Networks, terminal pairs, relationship of two port variables, impedance parameters, admittance parameters, transmission parameters and hybrid parameters, interconnections of two port networks.

Text / References:

1. M. E. Van Valkenburg, “Network Analysis”, Prentice Hall, 2006.
2. D. Roy Choudhury, “Networks and Systems”, New Age International Publications, 1998.
3. W. H. Hayt and J. E. Kemmerly, “Engineering Circuit Analysis”, McGraw Hill Education, 2013.
4. C. K. Alexander and M. N. O. Sadiku, “Electric Circuits”, McGraw Hill Education, 2004.
5. K. V. V. Murthy and M. S. Kamath, “Basic Circuit Analysis”, Jaico Publishers, 1999.

PCC-EE02	**Analog Electronic Circuits**	**3L:0T:0P**	**3 credits**

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Understand the characteristics of transistors.
- Design and analyse various rectifier and amplifier circuits.
- Design sinusoidal and non-sinusoidal oscillators.
- Understand the functioning of OP-AMP and design OP-AMP based circuits.

Module 1: Diode circuits (4 Hours)

P-N junction diode, I-V characteristics of a diode; review of half-wave and full-wave rectifiers, Zener diodes, clamping and clipping circuits.

Module 2: BJT circuits (8 Hours)

Structure and I-V characteristics of a BJT; BJT as a switch. BJT as an amplifier: small-signal model, biasing circuits, current mirror; common-emitter, common-base and common-collector amplifiers; Small signal equivalent circuits, high-frequency equivalent circuits

Module 3: MOSFET circuits (8 Hours)

MOSFET structure and I-V characteristics. MOSFET as a switch. MOSFET as an amplifier: small-signal model and biasing circuits, common-source, common-gate and common-drain amplifiers; small signal equivalent circuits - gain, input and output impedances, trans-conductance, high frequency equivalent circuit.

Module 4: Differential, multi-stage and operational amplifiers (8 Hours)

Differential amplifier; power amplifier; direct coupled multi-stage amplifier; internal structure of an operational amplifier, ideal op-amp, non-idealities in an op-amp (Output offset voltage, input bias current, input offset current, slew rate, gain bandwidth product)

Module 5: Linear applications of op-amp (8 Hours)

Idealized analysis of op-amp circuits. Inverting and non-inverting amplifier, differential amplifier, instrumentation amplifier, integrator, active filter, P, PI and PID controllers and lead/lag compensator using an op-amp, voltage regulator, oscillators (Wein bridge and phase shift).

Analog to Digital Conversion.

Module 6: Nonlinear applications of op-amp (6 Hours)

Hysteretic Comparator, Zero Crossing Detector, Square-wave and triangular-wave generators. Precision rectifier, peak detector. Monoshot.

Text/References:

1. A. S. Sedra and K. C. Smith, “Microelectronic Circuits”, New York, Oxford University Press, 1998.
2. J. V. Wait, L. P. Huelsman and G. A. Korn, “Introduction to Operational Amplifier theory and applications”, McGraw Hill U. S., 1992.
3. J. Millman and A. Grabel, “Microelectronics”, McGraw Hill Education, 1988.

4. P. Horowitz and W. Hill, “The Art of Electronics”, Cambridge University Press, 1989.
5. P. R. Gray, R. G. Meyer and S. Lewis, “Analysis and Design of Analog Integrated Circuits”, John Wiley & Sons, 2001.

PCC-EE03: Analog Electronic Circuits Laboratory (0:0:2 – 1 credit)

Hands-on experiments related to the course contents of EE02.

PCC-EE04	Electrical Machines-I	3L:0T:0P	3 credits

Course Outcomes:
At the end of this course, students will demonstrate the ability to

- Understand the concepts of magnetic circuits.
- Understand the operation of dc machines.
- Analyse the differences in operation of different dc machine configurations.
- Analyse single phase and three phase transformers circuits.

Magnetic fields and magnetic circuits (6 Hours)
Review of magnetic circuits - MMF, flux, reluctance, inductance; review of Ampere Law and Biot Savart Law; Visualization of magnetic fields produced by a bar magnet and a current carrying coil - through air and through a combination of iron and air; influence of highly permeable materials on the magnetic flux lines.

Module 2: Electromagnetic force and torque (9 Hours)
B-H curve of magnetic materials; flux-linkage vs current characteristic of magnetic circuits; linear and nonlinear magnetic circuits; energy stored in the magnetic circuit; force as a partial derivative of stored energy with respect to position of a moving element; torque as a partial derivative of stored energy with respect to angular position of a rotating element. Examples - galvanometer coil, relay contact, lifting magnet, rotating element with eccentricity or saliency

Module 3: DC machines (8 Hours)
Basic construction of a DC machine, magnetic structure - stator yoke, stator poles, pole-faces or shoes, air gap and armature core, visualization of magnetic field produced by the field winding excitation with armature winding open, air gap flux density distribution, flux per pole, induced EMF in an armature coil. Armature winding and commutation - Elementary armature coil and commutator, lap and wave windings, construction of commutator, linear commutation Derivation of back EMF equation, armature MMF wave, derivation of torque equation, armature reaction, air gap flux density distribution with armature reaction.

Module 4: DC machine - motoring and generation (7 Hours)
Armature circuit equation for motoring and generation, Types of field excitations - separately excited, shunt and series. Open circuit characteristic of separately excited DC generator, back EMF with armature reaction, voltage build-up in a shunt generator, critical field resistance and critical speed. V-I characteristics and torque-speed characteristics of separately excited,

shunt and series motors. Speed control through armature voltage. Losses, load testing and back-to-back testing of DC machines

Module 5: Transformers (12 Hours)

Principle, construction and operation of single-phase transformers, equivalent circuit, phasor diagram, voltage regulation, losses and efficiency Testing - open circuit and short circuit tests, polarity test, back-to-back test, separation of hysteresis and eddy current losses Three-phase transformer - construction, types of connection and their comparative features, Parallel operation of single-phase and three-phase transformers, Autotransformers - construction, principle, applications and comparison with two winding transformer, Magnetizing current, effect of nonlinear B-H curve of magnetic core material, harmonics in magnetization current, Phase conversion - Scott connection, three-phase to six-phase conversion, Tap-changing transformers - No-load and on-load tap-changing of transformers, Three-winding transformers. Cooling of transformers.

Text / References:

1. A. E. Fitzgerald and C. Kingsley, "Electric Machinery", New York, McGraw Hill Education, 2013.
2. A. E. Clayton and N. N. Hancock, "Performance and design of DC machines", CBS Publishers, 2004.
3. M. G. Say, "Performance and design of AC machines", CBS Publishers, 2002.
4. P. S. Bimbhra, "Electrical Machinery", Khanna Publishers, 2011.
5. I. J. Nagrath and D. P. Kothari, "Electric Machines", McGraw Hill Education, 2010.

PCC-EE05: Electrical Machines Laboratory– I (0:0:2 – 1 credit)

Hands-on experiments related to the course contents of EE04.

PCC-EE06	Electromagnetic Fields	3L:1T:0P	4 credits

Course Outcomes:

At the end of the course, students will demonstrate the ability

- To understand the basic laws of electromagnetism.
- To obtain the electric and magnetic fields for simple configurations under static conditions.
- To analyse time varying electric and magnetic fields.
- To understand Maxwell's equation in different forms and different media.
- To understand the propagation of EM waves.

This course shall have Lectures and Tutorials. Most of the students find difficult to visualize electric and magnetic fields. Instructors may demonstrate various simulation tools to visualize electric and magnetic fields in practical devices like transformers, transmission lines and machines.

Module 1: **Review of Vector Calculus (6 hours)**
Vectoralgebra-addition,subtraction, componentsofvectors,scalarandvectormultiplications,tripleproducts, threeorthogonalcoordinatesystems (rectangular, cylindrical and spherical). Vectorcalculus-differentiation,partialdifferentiation,integration,vector operatordel,gradient,divergence and curl;integraltheoremsofvectors. Conversionofavectorfromonecoordinatesystemtoanother.

Module 2: Static Electric Field (6 Hours)
Coulomb's law, Electric field intensity, Electrical field due to point charges. Line, Surface and Volume charge distributions. Gauss law and its applications. Absolute Electric potential, Potential difference, Calculation of potential differences for different configurations. Electric dipole, Electrostatic Energy and Energy density.

Module 3: Conductors, Dielectrics and Capacitance (6 Hours)
Current and current density, Ohms Law in Point form, Continuity of current, Boundary conditions of perfect dielectric materials. Permittivity of dielectric materials, Capacitance, Capacitance of a two wire line, Poisson's equation, Laplace's equation, Solution of Laplace and Poisson's equation, Application of Laplace's and Poisson's equations.

Module 4: Static Magnetic Fields (6 Hours)
Biot-Savart Law, Ampere Law, Magnetic flux and magnetic flux density, Scalar and Vector Magnetic potentials. Steady magnetic fields produced by current carrying conductors.

Module 5: Magnetic Forces, Materials and Inductance (6 Hours)
Force on a moving charge, Force on a differential current element, Force between differential current elements, Nature of magnetic materials, Magnetization and permeability, Magnetic boundary conditions, Magnetic circuits, inductances and mutual inductances.

Module 6: Time Varying Fields and Maxwell's Equations (6 Hours)
Faraday's law for Electromagnetic induction, Displacement current, Point form of Maxwell's equation, Integral form of Maxwell's equations, Motional Electromotive forces. Boundary Conditions.

Module 7: Electromagnetic Waves (6 Hours)
Derivation of Wave Equation, Uniform Plane Waves, Maxwell's equation in Phasor form, Wave equation in Phasor form, Plane waves in free space and in a homogenous material. Wave equation for a conducting medium, Plane waves in lossy dielectrics, Propagation in good conductors, Skin effect. Poynting theorem.

Text / References:

1. M. N. O. Sadiku, "Elements of Electromagnetics", Oxford University Publication, 2014.
2. A. Pramanik, "Electromagnetism - Theory and applications", PHI Learning Pvt. Ltd, New Delhi, 2009.
3. A. Pramanik, "Electromagnetism-Problems with solution", Prentice Hall India, 2012.
4. G. W. Carter, "The electromagnetic field in its engineering aspects", Longmans, 1954.
5. W. J. Duffin, "Electricity and Magnetism", McGraw Hill Publication, 1980.
6. W. J. Duffin, "Advanced Electricity and Magnetism", McGraw Hill, 1968.

7. E. G. Cullwick, "The Fundamentals of Electromagnetism", Cambridge University Press, 1966.
8. B. D. Popovic, "Introductory Engineering Electromagnetics", Addison-Wesley Educational Publishers, International Edition, 1971.
9. W. Hayt, "Engineering Electromagnetics", McGraw Hill Education, 2012.

PCC-EE07	Digital Electronics	3L:0T:0P	3 credits

CourseOutcomes:

At the end of this course, students will demonstrate the ability to

- Understand working of logic families and logic gates.
- Design and implement Combinational and Sequential logiccircuits.
- Understand the process of Analog to Digital conversion and Digital to Analog conversion.
- Be able to use PLDs to implement the given logical problem.

Module 1:Fundamentals of Digital Systems and logicfamilies (7Hours)

Digital signals, digital circuits, AND, OR, NOT, NAND, NOR and Exclusive-OR operations, Boolean algebra, examples ofICgates, number systems-binary, signed binary, octal hexadecimal number, binaryarithmetic,one's and two's complements arithmetic, codes, error detecting and correctingcodes,characteristics of digital lCs, digital logic families, TTL, Schottky TTL and CMOS logic, interfacing CMOS and TTL, Tri-statelogic.

Module 2: Combinational DigitalCircuits (7Hours)

Standard representation for logic functions, K-map representation, simplification oflogicfunctions using K-map, minimization of logical functions. Don't care conditions, Multiplexer,De-Multiplexer/Decoders, Adders, Subtractors, BCD arithmetic, carry look ahead adder,serialadder, ALU, elementary ALU design, popular MSI chips, digital comparator,paritychecker/generator, code converters, priority encoders, decoders/drivers for display devices,Q-M method of functionrealization.

Module 3: Sequential circuits and systems (7Hours)

A 1-bit memory, the circuit properties of Bistable latch, the clocked SR flip flop, J- K-T andD-typesflipflops,applicationsofflipflops,shiftregisters,applicationsofshiftregisters,serialtoparallel converter, parallel to serial converter, ring counter, sequence generator,ripple(Asynchronous) counters, synchronous counters, counters design using flip flops,specialcounter IC's, asynchronous sequential counters, applications ofcounters.

Module 4: A/D and D/A Converters (7Hours)

Digital to analog converters: weighted resistor/converter, R-2R Ladder D/Aconverter,specifications for D/A converters, examples of D/A converter lCs, sample and hold circuit,analog to digital converters: quantization and encoding, parallel comparator A/Dconverter,successive approximation A/D converter, counting A/D converter, dual slope A/Dconverter,A/Dconverterusing voltagetofrequencyandvoltagetotimeconversion,specificationsofA/Dconverters, example of A/D converterICs

Module 5: Semiconductor memories and Programmable logic devices. (7Hours)
Memory organization and operation, expanding memory size, classification andcharacteristicsof memories, sequential memory, read only memory (ROM), read and write memory(RAM), content addressable memory (CAM), charge de coupled device memory (CCD), commonly used memory chips, ROM as a PLD, Programmable logic array, Programmable array logic, complex Programmable logic devices (CPLDS), Field Programmable Gate Array (FPGA).

Text/References:

1. R. P. Jain, "Modern Digital Electronics", McGraw Hill Education, 2009.
2. M. M. Mano, "Digital logic and Computer design", Pearson Education India, 2016.
3. A. Kumar, "Fundamentals of Digital Circuits", Prentice Hall India, 2016.

PCC-EE08: Digital Electronics Laboratory (0:0:2 – 1 credit)
Hands-on experiments related to the course contents of EE07.

PCC-EE09	Electrical Machines – II	3L:0T:0P	3 credits

Course Outcomes:
At the end of this course, students will demonstrate the ability to

- Understand the concepts of rotating magnetic fields.
- Understand the operation of ac machines.
- Analyse performance characteristics of ac machines.

Module 1: Fundamentals of AC machine windings (8 Hours)
Physical arrangement of windings in stator and cylindrical rotor; slots for windings; single-turn coil - active portion and overhang; full-pitch coils, concentrated winding, distributed winding, winding axis, 3D visualization of the above winding types, Air-gap MMF distribution with fixed current through winding - concentrated and distributed, Sinusoidally distributed winding, winding distribution factor

Module 2: Pulsating and revolving magnetic fields (4 Hours)
Constant magnetic field, pulsating magnetic field - alternating current in windings with spatial displacement, Magnetic field produced by a single winding - fixed current and alternating current
Pulsating fields produced by spatially displaced windings, Windings spatially shifted by 90 degrees, Addition of pulsating magnetic fields, Three windings spatially shifted by 120 degrees (carrying three-phase balanced currents), revolving magnetic field.

Module 3: Induction Machines (12 Hours)
Construction, Types (squirrel cage and slip-ring), Torque Slip Characteristics, Starting and Maximum Torque. Equivalent circuit. Phasor Diagram, Losses and Efficiency. Effect of

parameter variation on torque speed characteristics (variation of rotor and stator resistances, stator voltage, frequency). Methods of starting, braking and speed control for induction motors.
Generator operation. Self-excitation. Doubly-Fed Induction Machines.

Module 4: Single-phase induction motors (6 Hours)
Constructional features, double revolving field theory, equivalent circuit, determination of parameters. Split-phase starting methods and applications

Module 5: Synchronous machines (10 Hours)
Constructional features, cylindrical rotor synchronous machine - generated EMF, equivalent circuit and phasor diagram, armature reaction, synchronous impedance, voltage regulation. Operating characteristics of synchronous machines, V-curves. Salient pole machine - two reaction theory, analysis of phasor diagram, power angle characteristics. Parallel operation of alternators - synchronization and load division.

Text/References:

1. A. E. Fitzgerald and C. Kingsley, "Electric Machinery”, McGraw Hill Education, 2013.
2. M. G. Say, “Performance and design of AC machines”, CBS Publishers, 2002.
3. P. S. Bimbhra, “Electrical Machinery”, Khanna Publishers, 2011.
4. I. J. Nagrath and D. P. Kothari, “Electric Machines”, McGraw Hill Education, 2010.
5. A. S. Langsdorf, “Alternating current machines”, McGraw Hill Education, 1984.
6. P. C. Sen, “Principles of Electric Machines and Power Electronics”, John Wiley & Sons, 2007.

PCC-EE10: Electrical Machines Laboratory– II (0:0:2 – 1 credit)

Hands-on experiments related to the course contents of EE09.

PCC-EE11	Power Electronics	3L:0T:0P	3 credits

Course Outcomes:
At the end of this course students will demonstrate the ability to

- Understand the differences between signal level and power level devices.
- Analyse controlled rectifier circuits.
- Analyse the operation of DC-DC choppers.
- Analyse the operation of voltage source inverters.

Module 1: Power switching devices (8Hours)
Diode, Thyristor, MOSFET, IGBT: I-V Characteristics; Firing circuit for thyristor; Voltage and current commutation of a thyristor; Gate drive circuits for MOSFET and IGBT.

Module 2: Thyristor rectifiers (7Hours)
Single-phase half-wave and full-wave rectifiers, Single-phase full-bridge thyristor rectifier with R-load and highly inductive load; Three-phase full-bridge thyristor rectifier with R-load and highly inductive load; Input current wave shape and power factor.

Module 3: DC-DC buck converter (5Hours)
Elementary chopper with an active switch and diode, concepts of duty ratio and average voltage, power circuit of a buck converter, analysis and waveforms at steady state, duty ratio control of output voltage.

Module 4: DC-DC boost converter (5Hours)
Power circuit of a boost converter, analysis and waveforms at steady state, relation between duty ratio and average output voltage.

Module 5: Single-phase voltage source inverter (10Hours)
Power circuit of single-phase voltage source inverter, switch states and instantaneous output voltage, square wave operation of the inverter, concept of average voltage over a switching cycle, bipolar sinusoidal modulation and unipolar sinusoidal modulation, modulation index and output voltage

Module 6: Three-phase voltage source inverter (8Hours)
Power circuit of a three-phase voltage source inverter, switch states, instantaneous output voltages, average output voltages over a sub-cycle, three-phase sinusoidal modulation

Text/References:

1. M. H. Rashid, "*Power electronics: circuits, devices, and applications*", Pearson Education India, 2009.
2. N. Mohan and T. M. Undeland, "Power Electronics: Converters, Applications and Design", John Wiley & Sons, 2007.
3. R. W. Erickson and D. Maksimovic, "Fundamentals of Power Electronics", Springer Science & Business Media, 2007.
4. L. Umanand, "Power Electronics: Essentials and Applications", Wiley India, 2009.

PCC-EE12: Power Electronics Laboratory (0:0:2 – 1 credit)

Hands-on experiments related to the course contents of EE11.

PCC-EE13	Signals and Systems	2L:1T:0P	3 credits

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Understand the concepts of continuous time and discrete time systems.
- Analyse systems in complex frequency domain.
- Understand sampling theorem and its implications.

Module 1: Introduction to Signals and Systems (3 hours):

Signals and systems as seen in everyday life, and in various branches of engineering and science. Signal properties: periodicity, absolute integrability, determinism and stochastic character. Some special signals of importance: the unit step, the unit impulse, the sinusoid, the complex exponential, some special time-limited signals; continuous and discrete time signals, continuous and discrete amplitude signals. System properties: linearity: additivity and homogeneity, shift-invariance, causality, stability, realizability. Examples.

Module 2: Behavior of continuous and discrete-time LTI systems (8 hours)

Impulse response and step response, convolution, input-output behavior with aperiodic convergent inputs, cascade interconnections. Characterization of causality and stability of LTI systems. System representation through differential equations and difference equations. State-space Representation of systems. State-Space Analysis, Multi-input, multi-output representation. State Transition Matrix and its Role. Periodic inputs to an LTI system, the notion of a frequency response and its relation to the impulse response.

Module 3: Fourier, Laplace and z- Transforms (10 hours)

Fourier series representation of periodic signals, Waveform Symmetries, Calculation of Fourier Coefficients. Fourier Transform, convolution/multiplication and their effect in the frequency domain, magnitude and phase response, Fourier domain duality. The Discrete-Time Fourier Transform (DTFT) and the Discrete Fourier Transform (DFT). Parseval's Theorem. Review of the Laplace Transform for continuous time signals and systems, system functions, poles and zeros of system functions and signals, Laplace domain analysis, solution to differential equations and system behavior. The z-Transform for discrete time signals and systems, system functions, poles and zeros of systems and sequences, z-domain analysis.

Module 4: Sampling and Reconstruction (4 hours)

The Sampling Theorem and its implications. Spectra of sampled signals. Reconstruction: ideal interpolator, zero-order hold, first-order hold. Aliasing and its effects. Relation between continuous and discrete time systems. Introduction to the applications of signal and system theory: modulation for communication, filtering, feedback control systems.

Text/References:

1. A. V. Oppenheim, A. S. Willsky and S. H. Nawab, “Signals and systems”, Prentice Hall India, 1997.
2. J. G. Proakis and D. G. Manolakis, “Digital Signal Processing: Principles, Algorithms, and Applications”, Pearson, 2006.
3. H. P. Hsu, “Signals and systems”, Schaum’s series, McGraw Hill Education, 2010.
4. S. Haykin and B. V. Veen, “Signals and Systems”, John Wiley and Sons, 2007.

5. A. V. Oppenheim and R. W. Schafer, “Discrete-Time Signal Processing”, Prentice Hall, 2009.
6. M. J. Robert “Fundamentals of Signals and Systems”, McGraw Hill Education, 2007.
7. B. P. Lathi, “Linear Systems and Signals”, Oxford University Press, 2009.

PCC-EE14:	Power Systems-I	3L:0T:0P	3 credits

Course Outcomes:
At the end of this course, students will demonstrate the ability to
- Understand the concepts of power systems.
- Understand the various power system components.
- Evaluate fault currents for different types of faults.
- Understand the generation of over-voltages and insulation coordination.
- Understand basicprotection schemes.
- Understand concepts of HVdc power transmission and renewable energy generation.

Module 1: Basic Concepts (4 hours)
Evolution of Power Systems and Present-Day Scenario. Structure of a power system: Bulk Power Grids and Micro-grids.
Generation: Conventional and Renewable Energy Sources. Distributed Energy Resources. Energy Storage. Transmission and Distribution Systems: Line diagrams, transmission and distribution voltage levels and topologies (meshed and radial systems). Synchronous Grids and Asynchronous (DC) interconnections. Review of Three-phase systems. Analysis of simple three-phase circuits. Power Transfer in AC circuits and Reactive Power.

Module 2: Power System Components (15 hours)
Overhead Transmission Lines and Cables: Electrical and Magnetic Fields around conductors, Corona. Parameters of lines and cables. Capacitance and Inductance calculations for simple configurations. Travelling-wave Equations. Sinusoidal Steady state representation of Lines: Short, medium and long lines. Power Transfer, Voltage profile and Reactive Power.
Characteristics of transmission lines. Surge Impedance Loading. Series and Shunt Compensation of transmission lines.

Transformers: Three-phase connections and Phase-shifts. Three-winding transformers, auto-transformers, Neutral Grounding transformers. Tap-Changing in transformers.
Transformer Parameters. Single phase equivalent of three-phase transformers.

Synchronous Machines: Steady-state performance characteristics. Operation when connected to infinite bus. Real and Reactive Power Capability Curve of generators. Typical waveform under balanced terminal short circuit conditions – steady state, transient and sub-transient equivalent circuits. Loads: Types, Voltage and Frequency Dependence of Loads. Per-unit System and per-unit calculations.

Module 3: Over-voltages and Insulation Requirements (4 hours)
Generation of Over-voltages: Lightning and Switching Surges. Protection against Over-voltages, Insulation Coordination. Propagation of Surges. Voltages produced by traveling surges. Bewley Diagrams.

Module 4: Fault Analysis and Protection Systems (10 hours)
Method of Symmetrical Components (positive, negative and zero sequences). Balanced and Unbalanced Faults. Representation of generators, lines and transformers in sequence networks. Computation of Fault Currents. Neutral Grounding.

Switchgear: Types of Circuit Breakers. Attributes of Protection schemes, Back-up Protection. Protection schemes (Over-current, directional, distance protection, differential protection) and their application.

Module 5: Introduction to DC Transmission & Renewable Energy Systems (9 hours)
DC Transmission Systems: Line-Commutated Converters (LCC) and Voltage Source Converters (VSC). LCC and VSC based dc link, Real Power Flow control in a dc link. Comparison of ac and dc transmission. Solar PV systems: I-V and P-V characteristics of PV panels, power electronic interface of PV to the grid. Wind Energy Systems: Power curve of wind turbine. Fixed and variable speed turbines. Permanent Magnetic Synchronous Generators and Induction Generators. Power Electronics interfaces of wind generators to the grid.

Text/References:

1. J. Grainger and W. D. Stevenson, “Power System Analysis”, McGraw Hill Education, 1994.
2. O. I. Elgerd, “Electric Energy Systems Theory”, McGraw Hill Education, 1995.
3. A. R. Bergen and V. Vittal, “Power System Analysis”, Pearson Education Inc., 1999.
4. D. P. Kothari and I. J. Nagrath, “Modern Power System Analysis”, McGraw Hill Education, 2003.
5. B. M. Weedy, B. J. Cory, N. Jenkins, J. Ekanayake and G. Strbac, “Electric Power Systems”, Wiley, 2012.

PCC-EE15: Power Systems – I Laboratory (0:0:2 – 1 credit)

Hands-on experiments related to the course contents of EE14. Visits to power system installations (generation stations, EHV substations etc.) are suggested. Exposure to fault analysis and Electro-magnetic transient program (EMTP) and Numerical Relays are suggested.

PCC-EE16	Control Systems	3L:0T:0P	3 credits

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Understand the modellingof linear-time-invariant systems using transfer function and state-space representations.
- Understandthe concept of stability and its assessment for linear-time invariant systems.
- Design simple feedback controllers.

Module 1: Introduction to control problem (4 hours)

Industrial Control examples. Mathematical models of physical systems. Control hardware and their models. Transfer function models of linear time-invariant systems.

Feedback Control: Open-Loop and Closed-loop systems. Benefits of Feedback. Block diagram algebra.

Module 2: Time Response Analysis (10 hours)

Standard test signals. Time response of first and second order systems for standard test inputs. Application of initial and final value theorem. Design specifications for second-order systems based on the time-response.

Concept of Stability. Routh-Hurwitz Criteria. Relative Stability analysis. Root-Locus technique. Construction of Root-loci.

Module 3: Frequency-response analysis (6 hours)

Relationship between time and frequency response, Polar plots, Bode plots. Nyquist stability criterion. Relative stability using Nyquist criterion – gain and phase margin. Closed-loop frequency response.

Module 4: Introduction to Controller Design (10 hours)

Stability, steady-state accuracy, transient accuracy, disturbance rejection, insensitivity and robustness of control systems.

Root-loci method of feedback controller design.

Design specifications in frequency-domain. Frequency-domain methods of design.

Application of Proportional, Integral and Derivative Controllers, Lead and Lag compensation in designs.

Analog and Digital implementation of controllers.

Module 5: State variable Analysis (6 hours)

Concepts of state variables. State space model. Diagonalization of State Matrix. Solution of state equations. Eigenvalues and Stability Analysis. Concept of controllability and observability.

Pole-placement by state feedback.

Discrete-time systems. Difference Equations. State-space models of linear discrete-time systems. Stability of linear discrete-time systems.

Module 6: Introduction to Optimal Control and NonlinearControl(5 hours)
Performance Indices. Regulator problem, Tracking Problem. Nonlinear system–Basic concepts and analysis.

Text/References:

1. M. Gopal, “Control Systems: Principles and Design”, McGraw Hill Education, 1997.
2. B. C. Kuo, “Automatic Control System”, Prentice Hall, 1995.
3. K. Ogata, “Modern Control Engineering”, Prentice Hall, 1991.
4. I. J. Nagrath and M. Gopal, “Control Systems Engineering”, New Age International, 2009

PCC-EE17: Control Systems Laboratory (0:0:2 – 1 credit)

Hands-on/Computer experiments related to the course contents of EE16.

PCC-EE18	Microprocessors	3L:0T:0P	3 credits

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Do assembly language programming.
- Do interfacing design of peripherals like I/O, A/D, D/A, timer etc.
- Develop systems using different microcontrollers.

Module 1: Fundamentals of Microprocessors: (7Hours)

Fundamentals of Microprocessor Architecture. 8-bitMicroprocessor and Microcontroller architecture, Comparison of 8-bit microcontrollers, 16-bit and 32-bit microcontrollers. Definition of embedded system and its characteristics, Role of microcontrollers in embedded Systems. Overview of the 8051 family.

Module 2 :The 8051 Architecture (8 Hours)

Internal Block Diagram, CPU, ALU, address, data and control bus, Working registers, SFRs, Clock and RESET circuits, Stack and Stack Pointer, Program Counter, I/O ports, Memory Structures, Data and Program Memory, Timing diagrams and Execution Cycles.

Module 3: Instruction Set and Programming (8 Hours)

Addressing modes: Introduction, Instruction syntax, Data types, Subroutines Immediate addressing, Register addressing, Direct addressing, Indirect addressing, Relative addressing, Indexed addressing, Bit inherent addressing, bit direct addressing. 8051 Instruction set, Instruction timings. Data transfer instructions, Arithmetic instructions, Logical instructions, Branch instructions, Subroutine instructions, Bit manipulation instruction. Assembly language programs, C language programs. Assemblers and compilers. Programming and debugging tools.

Module4: Memory and I/O Interfacing (6 Hours):

Memory and I/O expansion buses, control signals, memory wait states. Interfacing of peripheral devices such as General Purpose I/O, ADC, DAC, timers, counters, memory devices.

Module 5: External Communication Interface (6 Hours)

Synchronous and Asynchronous Communication. RS232, SPI, I2C. Introduction and interfacing to protocols like Blue-tooth and Zig-bee.

Module6: Applications (06 Hours)

LED, LCD and keyboard interfacing. Stepper motor interfacing, DC Motor interfacing, sensor interfacing.

Text / References:

1. M. A.Mazidi, J. G. Mazidi and R. D. McKinlay, “The8051Microcontroller and Embedded Systems: Using Assembly and C”,Pearson Education, 2007.
2. K. J. Ayala, “8051 Microcontroller”, Delmar Cengage Learning,2004.
3. R. Kamal, “Embedded System”, McGraw Hill Education,2009.
4. R. S. Gaonkar, “, Microprocessor Architecture: Programming and Applications with the 8085”, Penram International Publishing, 1996

5. D. A. Patterson and J. H. Hennessy, "Computer Organization and Design: The Hardware/Software interface”, Morgan Kaufman Publishers, 2013.
6. D. V. Hall, “Microprocessors & Interfacing”, McGraw Hill Higher Education, 1991.

PCC-EE19: Microprocessor Laboratory (0:0:2 – 1 credit)

Hands-on experiments related to the course contents of EE18.

PCC-EE20	Power Systems – II	3L:0T:0P	3 credits

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Use numerical methods to analyse a power system in steady state.
- Understand stability constraints in a synchronous grid.
- Understand methods to control the voltage, frequency and power flow.
- Understand the monitoring and control of a power system.
- Understand the basics of power system economics.

Module 1: Power Flow Analysis (7 hours)

Review of the structure of a Power System and its components. Analysis of Power Flows: Formation of Bus Admittance Matrix. Real and reactive power balance equations at a node. Load and Generator Specifications. Application of numerical methods for solution of non-linear algebraic equations – Gauss Seidel and Newton-Raphson methods for the solution of the power flow equations. Computational Issues in Large-scale Power Systems.

Module 2: Stability Constraints in synchronous grids (8 hours)

Swing Equations of a synchronous machine connected to an infinite bus. Power angle curve. Description of the phenomena of loss of synchronism in a single-machine infinite bus system following a disturbance like a three--phase fault. Analysis using numerical integration of swing equations (using methods like Forward Euler, Runge-Kutta 4th order methods), as well as the Equal Area Criterion. Impact of stability constraints on Power System Operation. Effect of generation rescheduling and series compensation of transmission lines on stability.

Module 3: Control of Frequency and Voltage (7 hours)

Turbines and Speed-Governors, Frequency dependence of loads, Droop Control and Power Sharing. Automatic Generation Control. Generation and absorption of reactive power by various components of a Power System. Excitation System Control in synchronous generators, Automatic Voltage Regulators. Shunt Compensators, Static VAR compensators and STATCOMs. Tap Changing Transformers.

Power flow control using embedded dc links, phase shifters and

Module 4: Monitoring and Control (6 hours)

Overview of Energy Control Centre Functions: SCADA systems. Phasor Measurement Units and Wide-Area Measurement Systems. State-estimation. System Security Assessment. Normal, Alert, Emergency, Extremis states of a Power System. Contingency Analysis. Preventive Control and Emergency Control.

Module 5: **Power System Economics and Management (7 hours)**

Basic Pricing Principles: Generator Cost Curves, Utility Functions, Power Exchanges, Spot Pricing. Electricity Market Models (Vertically Integrated, Purchasing Agency, Whole-sale competition, Retail Competition), Demand Side-management, Transmission and Distributions charges, Ancillary Services. Regulatory framework.

Text/References:

1. J. Grainger and W. D. Stevenson, “Power System Analysis”, McGraw Hill Education, 1994.
2. O. I. Elgerd, “Electric Energy Systems Theory”, McGraw Hill Education, 1995.
3. A. R. Bergen and V. Vittal, “Power System Analysis”, Pearson Education Inc., 1999.
4. D. P. Kothari and I. J. Nagrath, “Modern Power System Analysis”, McGraw Hill Education, 2003.
5. B. M. Weedy, B. J. Cory, N. Jenkins, J. Ekanayake and G. Strbac, “Electric Power Systems”, Wiley, 2012.

PCC-EE21: Power Systems-II Laboratory (0:0:2 – 1 credit)

Hands-on and computational experiments related to the course contents of EE20. This should include programming of numerical methods for solution of the power flow problem and stability analysis. Visit to load dispatch centre is suggested.

PCC-EE22	Measurements and Instrumentation Laboratory	2L:0T:2P	3 credits

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Design and validate DC and AC bridges.
- Analyze the dynamic response and the calibration of few instruments.
- Learn about various measurement devices, their characteristics, their operation and their limitations.
- Understand statistical data analysis.
- Understand computerized data acquisition.

Lectures/Demonstrations:

1. Concepts relating to Measurements: True value, Accuracy, Precision, Resolution, Drift, Hysteresis, Dead-band, Sensitivity.
2. Errors in Measurements. Basic statistical analysis applied to measurements: Mean, Standard Deviation, Six-sigma estimation, C_p, C_{pk}.
3. Sensors and Transducers for physical parameters: temperature, pressure, torque, flow. Speed and Position Sensors.
4. Current and Voltage Measurements. Shunts, Potential Dividers. Instrument Transformers, Hall Sensors.
5. Measurements of R, L and C.
6. Digital Multi-meter, True RMS meters, Clamp-on meters, Meggers.
7. Digital Storage Oscilloscope.

Experiments

1. Measurement of a batch of resistors and estimating statistical parameters.
2. Measurement of L using a bridge technique as well as LCR meter.
3. Measurement of C using a bridge technique as well as LCR meter.
4. Measurement of Low Resistance using Kelvin’s double bridge.
5. Measurement of High resistance and Insulation resistance using Megger.
6. Usage of DSO for steady state periodic waveforms produced by a function generator. Selection of trigger source and trigger level, selection of time-scale and voltage scale. Bandwidth of measurement and sampling rate.
7. Download of one-cycle data of a periodic waveform from a DSO and use values to compute the RMS values using a C program.
8. Usage of DSO to capture transients like a step change in R-L-C circuit.
9. Current Measurement using Shunt, CT, and Hall Sensor.

PCC-EE23	Electronics Design Laboratory	1L:0T:4P	3 credits

Course Outcomes:

At the end of the course, studentswilldemonstrate the ability to

- Understandthe practical issues related to practicalimplementation of applications usingelectronic circuits.
- Chooseappropriate components, software and hardware platforms.
- Design a Printed Circuit Board, getit made and populate/solder itwith components.
- Work as a team withotherstudents to implement an application.

Basic concepts on measurements; Noise in electronic systems; Sensors and signal conditioning circuits; Introduction to electronic instrumentation and PC based data acquisition; Electronic system design, Analog system design, Interfacing of analog and digital systems, Embedded systems, Electronic system design employing microcontrollers, CPLDs, and FPGAs, PCB design and layout; System assembly considerations. Group projects involving electronic hardware (Analog, Digital, mixed signal) leading to implementation of an application.

Text/Reference Books

1. A. S. Sedra and K. C. Smith, "Microelectronic circuits", Oxford University Press, 2007.
2. P. Horowitz and W. Hill, "The Art of Electronics", Cambridge University Press, 1997.
3. H.W.Ott, "Noise Reduction Techniques in Electronic Systems", Wiley, 1989.
4. W.C. Bosshart, "Printed Circuit Boards: Design and Technology", Tata McGraw Hill, 1983.
5. G.L. Ginsberg, "Printed Circuit Design", McGraw Hill, 1991.

PROFESSIONAL ELECTIVE COURSES

PEC-EE01	**Wind and Solar Energy Systems**	**3L:0T:0P**	**3 credits**

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Understand the energy scenario and the consequent growth of the power generation from renewable energy sources.
- Understand the basic physics of wind and solar power generation.
- Understand the power electronic interfaces for wind and solar generation.
- Understand the issues related to the grid-integration of solar and wind energy systems.

Module 1: Physics of Wind Power: (5 Hours)

History of wind power, Indian and Global statistics, Wind physics, Betz limit, Tip speed ratio, stall and pitch control, Wind speed statistics-probability distributions, Wind speed and power-cumulative distribution functions.

Module 2: Wind generator topologies: (12 Hours)

Review of modern wind turbine technologies,Fixed and Variable speed wind turbines, Induction Generators, Doubly-Fed Induction Generators and their characteristics, Permanent-Magnet Synchronous Generators, Power electronics converters. Generator-Converter configurations, Converter Control.

Module 3: The Solar Resource: (3 Hours)

Introduction, solar radiation spectra, solar geometry, Earth Sun angles, observer Sun angles, solar day length, Estimation of solar energy availability.

Module 4: Solar photovoltaic: (8 Hours)

Technologies-Amorphous, monocrystalline, polycrystalline; V-I characteristics of a PV cell, PV module, array, Power Electronic Converters for Solar Systems, Maximum Power Point Tracking (MPPT) algorithms.Converter Control.

Module 5: Network Integration Issues: (8 Hours)

Overview of grid code technical requirements. Fault ride-through for wind farms - real and reactive power regulation, voltage and frequency operating limits, solar PV and wind farm behavior during grid disturbances. Power quality issues. Power system interconnection experiences in the world. Hybrid and isolated operations of solar PV and wind systems.

Module 6: Solar thermal power generation: (3 Hours)

Technologies, Parabolic trough, central receivers, parabolic dish, Fresnel, solar pond, elementary analysis.

Text / References:

1. T. Ackermann, "Wind Power in Power Systems", John Wiley and Sons Ltd., 2005.
2. G. M. Masters, "Renewable and Efficient Electric Power Systems**",** John Wiley and Sons, 2004.
3. S. P. Sukhatme, "Solar Energy: Principles of Thermal Collection and Storage", McGraw Hill, 1984.
4. H. Siegfried and R. Waddington, "Grid integration of wind energy conversion systems" John Wiley and Sons Ltd., 2006.
5. G. N. Tiwari and M. K. Ghosal, "Renewable Energy Applications", Narosa Publications, 2004.
6. J. A. Duffie and W. A. Beckman, "Solar Engineering of Thermal Processes", John Wiley & Sons, 1991.

PEC-EE02	Line-Commutated and Active PWM Rectifiers	3L:0T:0P	3 credits

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Analyse controlled rectifier circuits.
- Understand the operation of line-commutated rectifiers – 6 pulse and multi-pulse configurations.
- Understand the operation of PWM rectifiers – operation in rectification and regeneration modes and lagging, leading and unity power factor mode.

Module 1: Diode rectifiers with passive filtering (6 Hours)

Half-wave diode rectifier with RL and RC loads; 1-phase full-wave diode rectifier with L, C and LC filter; 3-phase diode rectifier with L, C and LC filter; continuous and discontinuous conduction, input current waveshape, effect of source inductance; commutation overlap.

Module 2: Thyristor rectifiers with passive filtering (6 Hours)

Half-wave thyristor rectifier with RL and RC loads; 1-phase thyristor rectifier with L and LC filter; 3-phase thyristor rectifier with L and LC filter; continuous and discontinuous conduction, input current waveshape.

Module 3: Multi-Pulse converter (6 Lectures)

Review of transformer phase shifting, generation of 6-phase ac voltage from 3-phase ac, 6-pulse converter and 12-pulse converters with inductive loads, steady state analysis, commutation overlap, notches during commutation.

Module 4: Single-phase ac-dc single-switch boost converter (6 Hours)

Review of dc-dc boost converter, power circuit of single-switch ac-dc converter, steady state analysis, unity power factor operation, closed-loop control structure.

Module 5: Ac-dc bidirectional boost converter (6 Hours)

Review of 1-phase inverter and 3-phase inverter, power circuits of 1-phase and 3-phase ac-dc boost converter, steady state analysis, operation at leading, lagging and unity power factors. Rectification and regenerating modes. Phasor diagrams, closed-loop control structure.

Module 6: Isolated single-phase ac-dc flyback converter (10 Hours)

Dc-dc flyback converter, output voltage as a function of duty ratio and transformer turns ratio. Power circuit of ac-dc flyback converter, steady state analysis, unity power factor operation, closed loop control structure.

Text / References:

1. G. De, "Principles of Thyristorised Converters", Oxford & IBH Publishing Co, 1988.
2. J.G. Kassakian, M. F. Schlecht and G. C. Verghese, "Principles of Power Electronics", Addison-Wesley, 1991.
3. L. Umanand, "Power Electronics: Essentials and Applications", Wiley India, 2009.
4. N. Mohan and T. M. Undeland, "Power Electronics: Converters, Applications and Design", John Wiley & Sons, 2007.
5. R. W. Erickson and D. Maksimovic, "Fundamentals of Power Electronics", Springer Science & Business Media, 2001.

PEC-EE03	Electrical Drives	3L:0T:0P	3 credits

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Understand the characteristicsof dc motors and induction motors.
- Understand the principles of speed-control of dc motors and induction motors.
- Understand the power electronic converters used for dc motor and induction motor speed control.

Module 1: DC motor characteristics (5 hours)

Review of emf and torque equations of DC machine, review of torque-speed characteristics of separately excited dc motor, change in torque-speed curve with armature voltage, example load torque-speed characteristics, operating point, armature voltage control for varying motor speed, flux weakening for high speed operation.

Module 2: Chopper fed DC drive (5 hours)

Review of dc chopper and duty ratio control, chopper fed dc motor for speed control, steady state operation of a chopper fed drive, armature current waveform and ripple, calculation of losses in dc motor and chopper, efficiency of dc drive, smooth starting.

Module 3: Multi-quadrant DC drive (6 hours)

Review of motoring and generating modes operation of a separately excited dc machine, four quadrant operation of dc machine; single-quadrant, two-quadrant and four-quadrant choppers; steady-state operation of multi-quadrant chopper fed dc drive, regenerative braking.

Module 4: Closed-loop control of DC Drive (6 hours)

Control structure of DC drive, inner current loop and outer speed loop, dynamic model of dc motor – dynamic equations and transfer functions, modeling of chopper as gain with switching delay, plant transfer function, for controller design, current controller specification and design, speed controller specification and design.

Module 5: Induction motor characteristics (6 hours)

Review of induction motor equivalent circuit and torque-speed characteristic, variation of torque-speed curve with (i) applied voltage, (ii) applied frequency and (iii) applied voltage and frequency, typical torque-speed curves of fan and pump loads, operating point, constant flux operation, flux weakening operation.

Module 6: Scalar control or constant V/f control of induction motor (6 hours)

Review of three-phase voltage source inverter, generation of three-phase PWM signals, sinusoidal modulation, space vector theory, conventional space vector modulation; constant V/f control of induction motor, steady-state performance analysis based on equivalent circuit, speed drop with loading, slip regulation.

Module 7: Control of slip ring induction motor (6 hours)

Impact of rotor resistance of the induction motor torque-speed curve, operation of slip-ring induction motor with external rotor resistance, starting torque, power electronic based rotor side control of slip ring motor, slip power recovery.

Text / References:

1. G. K. Dubey, “Power Semiconductor Controlled Drives”, Prentice Hall, 1989.
2. R. Krishnan, “Electric Motor Drives: Modeling, Analysis and Control”, Prentice Hall, 2001.
3. G. K. Dubey, “Fundamentals of Electrical Drives”, CRC Press, 2002.
4. W. Leonhard, “Control of Electric Drives”, Springer Science & Business Media, 2001.

PEC-EE04	Electrical and Hybrid Vehicles	3L:0T:0P	3 credits

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Understand the models to describe hybrid vehicles and their performance.
- Understand the different possible ways of energy storage.
- Understand the different strategies related to energy storage systems.

Module 1: Introduction (10 hours)

Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance.

Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies.

Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.

Module 3: Electric Trains (10 hours)

Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis. Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

Module 4: Energy Storage (10 hours)

Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems

Module 5: Energy Management Strategies (9 hours)

Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies.

Case Studies: Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).

Text / References:

1. C. Mi, M. A. Masrur and D. W. Gao, “Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives”, John Wiley & Sons, 2011.
2. S. Onori, L. Serrao and G. Rizzoni, “Hybrid Electric Vehicles: Energy Management Strategies”, Springer, 2015.
3. M. Ehsani, Y. Gao, S. E. Gay and A. Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design”, CRC Press, 2004.
4. T. Denton, “Electric and Hybrid Vehicles”, Routledge, 2016.

PEC-EE05	Electrical Machine Design	3L:0T:0P	3 credits

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Understand the constructionand performance characteristics of electrical machines.
- Understand the various factors which influence the design: electrical, magnetic and thermal loading of electrical machines
- Understand the principles of electrical machine design and carry out a basic design of an ac machine.
- Use software tools to do design calculations.

Module 1: Introduction

Major considerations in electrical machine design, electrical engineering materials, space factor, choice of specific electrical and magnetic loadings, thermal considerations, heat flow, temperature rise, rating of machines.

Module 2: Transformers

Sizing of a transformer, main dimensions, kVA output for single- and three-phase transformers, window space factor, overall dimensions, operating characteristics, regulation, no load current, temperature rise in transformers, design of cooling tank, methods for cooling of transformers.

Module 3: Induction Motors

Sizing of an induction motor, main dimensions, length of air gap, rules for selecting rotor slots of squirrel cage machines, design of rotor bars & slots, design of end rings, design of wound rotor, magnetic leakage calculations, leakage reactance of polyphase machines, magnetizing current, short circuit current, circle diagram, operating characteristics.

Module 4: Synchronous Machines

Sizing of a synchronous machine, main dimensions, design of salient pole machines, short circuit ratio, shape of pole face, armature design, armature parameters, estimation of air gap length, design of rotor, design of damper winding, determination of full load field mmf, design of field winding, design of turbo alternators, rotor design.

Module 5: **Computer aided Design (CAD):**

Limitations (assumptions) of traditional designs, need for CAD analysis, synthesis and hybrid methods, design optimization methods, variables, constraints and objective function, problem formulation. Introduction to FEM based machine design. Introduction to **c**omplex structures of modern machines-PMSMs, BLDCs, SRM and claw-pole machines.

Text / References:

1. A. K. Sawhney, "A Course in Electrical Machine Design", Dhanpat Rai and Sons, 1970.
2. M.G. Say, "Theory & Performance & Design of A.C. Machines", ELBS London.
3. S. K. Sen, "Principles of Electrical Machine Design with computer programmes", Oxford and IBH Publishing, 2006.

4. K. L. Narang, “A Text Book of Electrical Engineering Drawings”, SatyaPrakashan, 1969.
5. A. Shanmugasundaram, G. Gangadharan and R. Palani, “Electrical Machine Design Data Book”, New Age International, 1979.
6. K. M. V. Murthy, “Computer Aided Design of Electrical Machines”, B.S. Publications, 2008.
7. Electrical machines and equipment design exercise examples using Ansoft’s Maxwell 2D machine design package.

PEC-EE06	**Power System Protection**	**3L:0T:0P**	**3 credits**

Course Outcomes: At the end of this course, students will demonstrate the ability to

- Understand the different components of a protection system.
- Evaluate fault current due to different types of fault in a network.
- Understand the protection schemes for different power system components.
- Understand the basic principles of digital protection.
- Understand system protection schemes, and the use of wide-area measurements.

Module 1: **Introduction and Components of a Protection System (4 hours)**
Principles of Power System Protection, Relays, Instrument transformers, Circuit Breakers

Module 2: Faults and Over-Current Protection (8 hours)
Review of Fault Analysis, Sequence Networks. Introduction to Overcurrent Protection and overcurrent relay co-ordination.

Module 3: **Equipment Protection Schemes(8 hours)**
Directional, Distance, Differential protection. Transformer and Generator protection. Bus bar Protection, Bus Bar arrangement schemes.

Module 4: **Digital Protection (8 hours)**
Computer-aided protection, Fourier analysis and estimation of Phasors from DFT. Sampling, aliasing issues.

Module 5: **Modeling and Simulation of Protection Schemes (8 hours)**
CT/PT modeling and standards, Simulation of transients using Electro-Magnetic Transients (EMT) programs. Relay Testing.

Module 6: **System Protection (4 hours)**
Effect of Power Swings on Distance Relaying. System Protection Schemes. Under-frequency, under-voltage and df/dt relays, Out-of-step protection, Synchro-phasors, Phasor Measurement Units and Wide-Area Measurement Systems (WAMS). Application of WAMS for improving protection systems.

Text/References

1. J. L. Blackburn, "Protective Relaying: Principles and Applications", Marcel Dekker, New York, 1987.
2. Y. G.Paithankar and S. R. Bhide, "Fundamentals of power system protection", Prentice Hall, India, 2010.
3. A. G. Phadke and J. S. Thorp, "Computer Relaying for Power Systems", John Wiley & Sons, 1988.
4. A. G. Phadke and J. S. Thorp, "Synchronized Phasor Measurements and their Applications", Springer, 2008.
5. D. Reimert, "Protective Relaying for Power Generation Systems", Taylor and Francis, 2006.

PEC-EE07:	**HVdc Transmission Systems**	**3L:0T:0P**	**3 credits**

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Understand the advantages of dc transmission over ac transmission.
- Understand the operation of Line Commutated Converters and Voltage Source Converters.
- Understand the control strategies used in HVdc transmission system.
- Understand the improvement of power system stability using an HVdc system.

Module 1:dc Transmission Technology (4 hours)

Comparison of AC and dc Transmission (Economics, Technical Performance and Reliability). Application of DC Transmission. Types of HVdc Systems. Components of a HVdc system. Line Commutated Converter and Voltage Source Converter based systems.

Module 2: Analysis of Line Commutated and Voltage Source Converters (10 hours)

Line Commutated Converters (LCCs): Six pulse converter, Analysis neglecting commutation overlap, harmonics, Twelve Pulse Converters. Inverter Operation. Effect of Commutation Overlap. Expressions for average dc voltage, AC current and reactive power absorbed by the converters. Effect of Commutation Failure, Misfire and Current Extinction in LCC links.

Voltage Source Converters (VSCs): Two and Three-level VSCs. PWM schemes: Selective Harmonic Elimination, Sinusoidal Pulse Width Modulation. Analysis of a six pulse converter. Equations in the rotating frame. Real and Reactive power control using a VSC.

Module 3:Control of HVdc Converters: (10 hours)

Principles of Link Control in a LCCHVdc system. Control Hierarchy, Firing Angle Controls – Phase-Locked Loop, Current and Extinction Angle Control, Starting and Stopping of a Link. Higher level Controllers Power control, Frequency Control, Stability Controllers. Reactive Power Control. Principles of Link Control in a VSC HVdc system: Power flow and dc Voltage Control. Reactive Power Control/AC voltage regulation.

Module 3:Components of HVdc systems: (8 hours)

Smoothing Reactors, Reactive Power Sources and Filters in LCC HVdc systems DC line: Corona Effects. Insulators, Transient Over-voltages. dc line faults in LCC systems. dc line faults in VSC systems. dc breakers. Monopolar Operation. Ground Electrodes.

Module 4:Stability Enhancement using HVdc Control (4 hours)

Basic Concepts: Power System Angular, Voltage and Frequency Stability. Power Modulation: basic principles – synchronous and asynchronous links. Voltage Stability Problem in AC/dc systems.

Module 5:MTdc Links (4 hours)

Multi-Terminal and Multi-Infeed Systems. Series and Parallel MTdc systems using LCCs. MTdc systems using VSCs. Modern Trends in HVdcTechnology. Introduction to Modular Multi-level Converters.

Text/References:

1. K. R. Padiyar, "HVDC Power Transmission Systems", New Age International Publishers, 2011.
2. J. Arrillaga, "High Voltage Direct Current Transmission", Peter Peregrinus Ltd., 1983.
3. E. W. Kimbark, "Direct Current Transmission", Vol.1, Wiley-Interscience, 1971.

PEC-EE08	Power Quality and FACTS	3L:0T:0P	3 credits

Course Outcomes:
At the end of this course, students will demonstrate the ability to

- Understand the characteristics of ac transmission and the effect of shunt and series reactive compensation.
- Understand the working principles of FACTS devices and their operating characteristics.
- Understand the basic concepts of power quality.
- Understand the working principles of devices to improve power quality.

Module 1: Transmission Lines and Series/Shunt Reactive Power Compensation (4 hours)

Basics of AC Transmission. Analysis of uncompensated AC transmission lines. Passive Reactive Power Compensation. Shunt and series compensation at the mid-point of an AC line. Comparison of Series and Shunt Compensation.

Module 2: Thyristor-based Flexible AC Transmission Controllers (FACTS) (6 hours)

Description and Characteristics of Thyristor-based FACTS devices: Static VAR Compensator (SVC), Thyristor Controlled Series Capacitor (TCSC), Thyristor Controlled Braking Resistor and Single Pole Single Throw (SPST) Switch. Configurations/Modes of Operation, Harmonics and control of SVC and TCSC. Fault Current Limiter.

Module 3: Voltage Source Converter based (FACTS) controllers (8 hours)

Voltage Source Converters (VSC): Six Pulse VSC, Multi-pulse and Multi-level Converters, Pulse-Width Modulation for VSCs. Selective Harmonic Elimination, Sinusoidal PWM and Space Vector Modulation. STATCOM: Principle of Operation, Reactive Power Control: Type I and Type II controllers, Static Synchronous Series Compensator (SSSC) and Unified Power Flow Controller (UPFC): Principle of Operation and Control. Working principle of Interphase Power Flow Controller. Other Devices: GTO Controlled Series Compensator. Fault Current Limiter.

Module 4: Application of FACTS (4 hours)

Application of FACTS devices for power-flow control and stability improvement. Simulation example of power swing damping in a single-machine infinite bus system using a TCSC. Simulation example of voltage regulation of transmission mid-point voltage using a STATCOM.

Module 5: Power Quality Problems in Distribution Systems (4 hours)

Power Quality problems in distribution systems: Transient and Steady state variations in voltage and frequency. Unbalance, Sags, Swells, Interruptions, Wave-form Distortions: harmonics, noise, notching, dc-offsets, fluctuations. Flicker and its measurement. Tolerance of Equipment: CBEMA curve.

Module 6: DSTATCOM (8 hours)

Reactive Power Compensation, Harmonics and Unbalance mitigation in Distribution Systems using DSTATCOM and Shunt Active Filters. Synchronous Reference Frame Extraction of Reference Currents. Current Control Techniques in for DSTATCOM.

Module 6: Dynamic Voltage Restorer and Unified Power Quality Conditioner (6 hours)

Voltage Sag/Swell mitigation: Dynamic Voltage Restorer – Working Principle and Control Strategies. Series Active Filtering. Unified Power Quality Conditioner (UPQC): Working Principle. Capabilities and Control Strategies.

Text/References

1. N. G. Hingorani and L. Gyugyi, “Understanding FACTS: Concepts and Technology of FACTS Systems”, Wiley-IEEE Press, 1999.
2. K. R. Padiyar, “FACTS Controllers in Power Transmission and Distribution”, New Age International (P) Ltd. 2007.
3. T. J. E. Miller, “Reactive Power Control in Electric Systems”, John Wiley and Sons, New York, 1983.
4. R. C. Dugan, “Electrical Power Systems Quality”, McGraw Hill Education, 2012.
5. G. T. Heydt, “Electric Power Quality”, Stars in a Circle Publications, 1991

PEC-EE09	High Voltage Engineering	3L:0T:0P	3 credits

Course outcomes:
At the end of the course, the student will demonstrate

- Understand the basic physics related to various breakdown processes in solid, liquid and gaseous insulating materials.
- Knowledge of generation and measurement of D. C., A.C., & Impulse voltages.
- Knowledge of tests on H. V. equipment and on insulating materials, as per the standards.
- Knowledge of how over-voltages arise in a power system, and protection against these over-voltages.

Module 1: Breakdown in Gases (8 Hours)
Ionization processes and de-ionization processes, Types of Discharge, Gases as insulating materials, Breakdown in Uniform gap, non-uniform gaps, Townsend's theory, Streamer mechanism, Corona discharge

Module 2: Breakdown in liquid and solid Insulating materials (7 Hours)
Breakdown in pure and commercial liquids, Solid dielectrics and composite dielectrics, intrinsic breakdown, electromechanical breakdown and thermal breakdown, Partial discharge, applications of insulating materials.

Module 3: Generation of High Voltages (7 Hours)
Generation of high voltages, generation of high D. C. and A.C. voltages, generation of impulse voltages, generation of impulse currents, tripping and control of impulse generators.

Module 4: Measurements of High Voltages and Currents (7 Hours)
Peak voltage, impulse voltage and high direct current measurement method, cathode ray oscillographs for impulse voltage and current measurement, measurement of dielectric constant and loss factor, partial discharge measurements.

Module 5: Lightning and Switching Over-voltages (7 Hours)
Charge formation in clouds, Stepped leader, Dart leader, Lightning Surges. Switching over-voltages, Protection against over-voltages, Surge diverters, Surge modifiers.

Module 6: High Voltage Testing of Electrical Apparatus and High Voltage Laboratories (7 Hours)
Various standards for HV Testing of electrical apparatus, IS, IEC standards, Testing of insulators and bushings, testing of isolators and circuit breakers, testing of cables, power transformers and some high voltage equipment, High voltage laboratory layout, indoor and outdoor laboratories, testing facility requirements, safety precautions in H. V. Labs.

Text/Reference Books

1. M. S. Naidu and V. Kamaraju, "High Voltage Engineering", McGraw Hill Education, 2013.
2. C. L. Wadhwa, "High Voltage Engineering", New Age International Publishers, 2007.

3. D. V. Razevig (Translated by Dr. M. P. Chourasia), "High Voltage Engineering Fundamentals", Khanna Publishers, 1993.
4. E. Kuffel, W. S. Zaengl and J. Kuffel, "High Voltage Engineering Fundamentals", Newnes Publication, 2000.
5. R. Arora and W. Mosch "High Voltage and Electrical Insulation Engineering", John Wiley & Sons, 2011.
6. Various IS standards for HV Laboratory Techniques and Testing

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PEC-EE10	Electrical Energy Conservation and Auditing	3L:0T:0P	3 credits

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Understand the current energy scenario and importance of energy conservation.
- Understand the concepts of energy management.
- Understand the methods of improving energy efficiency in different electrical systems.
- Understand the concepts of different energy efficient devices.

Module 1: Energy Scenario (6 Hours)

Commercial and Non-commercial energy, primary energy resources, commercial energy production, final energy consumption, energy needs of growing economy, long term energy scenario, energy pricing, energy sector reforms, energy and environment, energy security, energy conservation and its importance, restructuring of the energy supply sector, energy strategy for the future, air pollution, climate change. Energy Conservation Act-2001 and its features.

Module 2: Basics of Energy and its various forms (7 Hours)

Electricity tariff, load management and maximum demand control, power factor improvement, selection & location of capacitors, Thermal Basics-fuels, thermal energy contents of fuel, temperature & pressure, heat capacity, sensible and latent heat, evaporation, condensation, steam, moist air and humidity & heat transfer, units and conversion.

Module 3: Energy Management & Audit (6 Hours)

Definition, energy audit, need, types of energy audit. Energy management (audit) approach-understanding energy costs, bench marking, energy performance, matching energy use to requirement, maximizing system efficiencies, optimizing the input energy requirements, fuel & energy substitution, energy audit instruments. Material and Energy balance: Facility as an energy system, methods for preparing process flow, material and energy balance diagrams.

Module 4: Energy Efficiency in Electrical Systems (7 Hours)

Electrical system: Electricity billing, electrical load management and maximum demand control, power factor improvement and its benefit, selection and location of capacitors, performance assessment of PF capacitors, distribution and transformer losses. Electric motors: Types, losses in induction motors, motor efficiency, factors affecting motor performance, rewinding and motor replacement issues, energy saving opportunities with energy efficient motors.

Module 5: Energy Efficiency in Industrial Systems (8 Hours)

Compressed Air System: Types of air compressors, compressor efficiency, efficient compressor operation, Compressed air system components, capacity assessment, leakage test, factors affecting the performance and savings opportunities in HVAC, Fans and blowers: Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities. Pumps and Pumping System: Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities.

Cooling Tower: Types and performance evaluation, efficient system operation, flow control strategies and energy saving opportunities, assessment of cooling towers.

Module 6: Energy Efficient Technologies in Electrical Systems (**8Hours**)

Maximum demand controllers, automatic power factor controllers, energy efficient motors, soft starters with energy saver, variable speed drives, energy efficient transformers, electronic ballast, occupancy sensors, energy efficient lighting controls, energy saving potential of each technology.

Text/Reference Books

1. Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-1, General Aspects (available online)
2. Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-3, Electrical Utilities (available online)
3. S. C. Tripathy, “Utilization of Electrical Energy and Conservation”, McGraw Hill, 1991.
4. Success stories of Energy Conservation by BEE, New Delhi (www.bee-india.org)

PEC-EE11	**Industrial Electrical Systems**	**3L:0T:0P**	**3 credits**

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Understand the electrical wiring systems for residential, commercial and industrial consumers, representing the systems with standard symbols and drawings, SLD.
- Understand various components of industrial electrical systems.
- Analyze and selectthe proper size of various electrical system components.

Module 1: Electrical System Components (8 Hours)
LT system wiring components, selection of cables, wires, switches, distribution box, metering system, Tariff structure, protection components- Fuse, MCB, MCCB, ELCB, inverse current characteristics, symbols, single line diagram (SLD) of a wiring system, Contactor, Isolator, Relays, MPCB, Electric shock and Electrical safety practices

Module 2: Residential and Commercial Electrical Systems (8 Hours)
Types of residential and commercial wiring systems, general rules and guidelines for installation, load calculation and sizing of wire, rating of main switch, distribution board and protection devices, earthing system calculations, requirements of commercial installation, deciding lighting scheme and number of lamps, earthing of commercial installation, selection and sizing of components.

Module 3: Illumination Systems (6 Hours)
Understanding various terms regarding light, lumen, intensity, candle power, lamp efficiency, specific consumption, glare, space to height ratio, waste light factor, depreciation factor, various illumination schemes, Incandescent lamps and modern luminaries like CFL, LED and their operation, energy saving in illumination systems, design of a lighting scheme for a residential and commercial premises, flood lighting.

Module 4: Industrial Electrical Systems I (8 Hours)
HT connection, industrial substation, Transformer selection, Industrial loads, motors, starting of motors, SLD, Cable and Switchgear selection, Lightning Protection, Earthing design, Power factor correction – kVAR calculations, type of compensation, Introduction to PCC, MCC panels. Specifications of LT Breakers, MCB and other LT panel components.

Module 5: Industrial Electrical Systems II (6 Hours)
DG Systems, UPS System, Electrical Systems for the elevators, Battery banks, Sizing the DG, UPS and Battery Banks, Selection of UPS and Battery Banks.

Module 6: Industrial Electrical System Automation (6 Hours)
Study of basic PLC, Role of in automation, advantages of process automation, PLC based control system design, Panel Metering and Introduction to SCADA system for distribution automation.

Text/Reference Books

2. S. L. Uppal and G. C. Garg, “Electrical Wiring, Estimating & Costing”, Khanna publishers, 2008.
3. K. B. Raina, “Electrical Design, Estimating & Costing”, New age International, 2007.
4. S. Singh and R. D. Singh, “Electrical estimating and costing”, Dhanpat Rai and Co., 1997.
5. Web site for IS Standards.
6. H. Joshi, “Residential Commercial and Industrial Systems”, McGraw Hill Education, 2008.

PEC-EE12	**Power System Dynamics and Control**	**3L:0T:0P**	**3 credits**

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Understand the problem of power system stability and its impact on the system.
- Analyse linear dynamical systems and use of numerical integration methods.
- Model different power system components for the study of stability.
- Understand the methods to improve stability.

Module 1: Introduction to Power System Operations (3 hours)

Introduction to power system stability. Power System Operations and Control. Stability problems in Power System. Impact on Power System Operations and control.

Module 2 : Analysis of Linear Dynamical System and Numerical Methods (5 hours)

Analysis of dynamical System, Concept of Equilibrium, Small and Large Disturbance Stability. Modal Analysis of Linear System. Analysisusing Numerical Integration Techniques. Issues in Modeling: Slow and Fast Transients, Stiff System.

Module 3 : Modeling of Synchronous Machines and Associated Controllers (12 hours)

Modeling of synchronous machine: Physical Characteristics. Rotor position dependent model. D-Q Transformation. Model with Standard Parameters. Steady State Analysis of Synchronous Machine. Short Circuit Transient Analysis of a Synchronous Machine. Synchronization of Synchronous Machine to an Infinite Bus. Modeling of Excitation and Prime Mover Systems. Physical Characteristics and Models. Excitation System Control. Automatic Voltage Regulator. Prime Mover Control Systems. Speed Governors.

Module 4 : Modeling of other Power System Components (10 hours)

Modeling of Transmission Lines and Loads. Transmission Line Physical Characteristics. Transmission Line Modeling. Load Models - induction machine model. Frequency and Voltage Dependence of Loads. Other Subsystems – HVDC and FACTS controllers, Wind Energy Systems.

Module 5 : Stability Analysis (11 hours)

Angular stability analysis in Single Machine Infinite Bus System. Angular Stability in multi-machine systems – Intra-plant, Local and Inter-area modes. Frequency Stability: Centre of Inertia Motion. Load Sharing: Governordroop. Single Machine Load Bus System: Voltage Stability. Introduction to Torsional Oscillations and the SSR phenomenon. Stability Analysis Tools:Transient Stability Programs, Small Signal Analysis Programs.

Module 6 : Enhancing System Stability (4 hours)

Planning Measures. Stabilizing Controllers (Power System Stabilizers). Operational Measures-Preventive Control. Emergency Control.

Text/Reference Books

1. K.R. Padiyar, “Power System Dynamics, Stability and Control”, B. S. Publications, 2002.
2. P. Kundur, “Power System Stability and Control”, McGraw Hill, 1995.
3. P. Sauer and M. A. Pai, “Power System Dynamics and Stability”, Prentice Hall, 1997.

PEC-EE13	**Digital Control Systems**	**3L:0T:0P**	**3 credits**

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Obtain discrete representation of LTI systems.
- Analyse stability of open loop and closed loop discrete-time systems.
- Design and analyse digital controllers.
- Design state feedback and output feedback controllers.

Module 1: Discrete Representation of Continuous Systems (6 hours)
Basics of Digital Control Systems. Discrete representation of continuous systems. Sample and hold circuit. Mathematical Modelling of sample and hold circuit. Effects of Sampling and Quantization. Choice of sampling frequency. ZOH equivalent.

Module 2: Discrete System Analysis (6 hours)
Z-Transform and Inverse Z Transform for analyzing discrete time systems. Pulse Transfer function. Pulse transfer function of closed loop systems. Mapping from s-plane to z plane. Solution of Discrete time systems. Time response of discrete time system.

Module 3: Stability of Discrete Time System (4 hours)
Stability analysis by Jury test. Stability analysis using bilinear transformation. Design of digital control system with dead beat response. Practical issues with dead beat response design.

Module 4: State Space Approach for discrete time systems (10 hours)
State space models of discrete systems, State space analysis. Lyapunov Stability. Controllability, reach-ability, Reconstructibility and observability analysis. Effect of pole zero cancellation on the controllability & observability.

Module 5: Design of Digital Control System(8 hours)
Design of Discrete PID Controller, Design of discrete state feedback controller. Design of set point tracker. Design of Discrete Observer for LTI System. Design of Discrete compensator.

Module 6: Discrete output feedback control (8 hours)
Design of discrete output feedback control. Fast output sampling (FOS) and periodic output feedback controller design for discrete time systems.

Text Books :

1. K. Ogata, "Digital Control Engineering", Prentice Hall, Englewood Cliffs, 1995.
2. M. Gopal, "Digital Control Engineering", Wiley Eastern, 1988.
3. G. F. Franklin, J. D. Powell and M. L. Workman, "Digital Control of Dynamic Systems", Addison-Wesley, 1998.
4. B.C. Kuo, "Digital Control System", Holt, Rinehart and Winston, 1980.

PEC-EE14	Digital Signal Processing	3L:0T:0P	3 credits

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Represent signals mathematically in continuous and discrete-time, and in the frequency domain.
- Analyse discrete-time systems using z-transform.
- Understand the Discrete-Fourier Transform (DFT) and the FFT algorithms.
- Design digital filters for various applications.
- Apply digital signal processing for the analysis of real-life signals.

Module 1: Discrete-time signals and systems (6 hours)

Discrete time signals and systems: Sequences; representation of signals on orthogonal basis; Representation of discrete systems using difference equations, Samplingand reconstruction of signals - aliasing; Sampling theorem and Nyquist rate.

Module 2: Z-transform (6 hours)

z-Transform, Region of Convergence, Analysis of Linear Shift Invariant systems using z-transform, Properties of z-transform for causal signals, Interpretation of stability in z-domain, Inverse z-transforms.

Module 2: Discrete Fourier Transform (10 hours)

Frequency Domain Analysis, Discrete Fourier Transform (DFT), Properties of DFT, Connvolution of signals, Fast Fourier Transform Algorithm, Parseval's Identity, Implementation of Discrete Time Systems.

Module 3:Designof Digital filters (12 hours)

Designof FIR Digital filters: Windowmethod,Park-McClellan's method. Design of IIR Digital Filters: Butterworth, Chebyshev and Elliptic Approximations;Low-pass, Band-pass, Band-stop and High-pass filters.

Effect of finite register length in FIR filter design. Parametric and non-parametric spectral estimation. Introduction to multi-rate signalprocessing.

Module 4: Applications of Digital Signal Processing (6 hours)

Correlation Functions and Power Spectra, Stationary Processes, Optimal filtering using ARMA Model, Linear Mean-Square Estimation, Wiener Filter.

Text/Reference Books:

1. S. K. Mitra, “Digital Signal Processing: A computer based approach”, McGraw Hill, 2011.
2. A.V. Oppenheim and R. W. Schafer, “Discrete Time Signal Processing”, Prentice Hall, 1989.
3. J. G. Proakis and D.G. Manolakis, “Digital Signal Processing: Principles, Algorithms And Applications”, Prentice Hall, 1997.
4. L. R. Rabiner and B. Gold, “Theory and Application of Digital Signal Processing”, Prentice Hall, 1992.
5. J. R. Johnson, “Introduction to Digital Signal Processing”, Prentice Hall, 1992.
6. D. J. DeFatta, J. G. Lucas andW. S. Hodgkiss, “Digital Signal Processing”, John Wiley & Sons, 1988.

PEC-EE15	Computer Architecture	3L:0T:0P	3 credits

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Understand the concepts of microprocessors, their principles and practices.
- Write efficient programs in assembly language of the 8086 family of microprocessors.
- Organize a modern computer system and be able to relate it to real examples.
- Develop the programs in assembly language for 80286, 80386 and MIPS processors in real and protected modes.
- Implement embedded applications using ATOM processor.

Module 1: Introduction to computer organization (6 hours)

Architecture and function of general computer system, CISC Vs RISC, Data types, Integer Arithmetic - Multiplication, Division, Fixed and Floating point representation and arithmetic, Control unit operation, Hardware implementation of CPU with Micro instruction, microprogramming, System buses, Multi-bus organization.

Module 2: Memory organization (6 hours)

System memory, Cache memory - types and organization, Virtual memory and its implementation, Memory management unit, Magnetic Hard disks, Optical Disks.

Module 3: Input – output Organization (8 hours)

Accessing I/O devices, Direct Memory Access and DMA controller, Interrupts and Interrupt Controllers, Arbitration, Multilevel Bus Architecture, Interface circuits - Parallel and serial port. Features of PCI and PCI Express bus.

Module 4: 16 and 32 microprocessors (8 hours)

80x86 Architecture, IA – 32 and IA – 64, Programming model, Concurrent operation of EU and BIU, Real mode addressing, Segmentation, Addressing modes of 80x86, Instruction set of 80x86, I/O addressing in 80x86

Module 5: Pipelining(8 hours)

Introduction to pipelining, Instruction level pipelining (ILP), compiler techniques for ILP, Data hazards, Dynamic scheduling, Dependability, Branch cost, Branch Prediction, Influence on instruction set.

Module 6: Different Architectures (8 hours)

VLIW Architecture, DSP Architecture, SoC architecture, MIPS Processor and programming

Text/Refence Books

1. V. Carl, G. Zvonko and S. G. Zaky, “Computer organization”, McGraw Hill, 1978.
2. B. Brey and C. R. Sarma, “The Intel microprocessors”, Pearson Education, 2000.
3. J. L. Hennessy and D. A. Patterson, “Computer Architecture A Quantitative Approach”, Morgan Kauffman, 2011.
4. W. Stallings, “Computer organization”, PHI, 1987.
5. P. Barry and P. Crowley, “Modern Embedded Computing”, Morgan Kaufmann, 2012.
6. N. Mathivanan, “Microprocessors, PC Hardware and Interfacing”, Prentice Hall, 2004.

7. Y. C. Lieu and G. A. Gibson, “Microcomputer Systems: The 8086/8088 Family”, Prentice Hall India, 1986.
8. J. Uffenbeck, “The 8086/8088 Design, Programming, Interfacing”, Prentice Hall, 1987.
9. B. Govindarajalu, “IBM PC and Clones”, Tata McGraw Hill, 1991.
10. P. Able, “8086 Assembly Language Programming”, Prentice Hall India.

PEC-EE16	Electromagnetic waves	3L:0T:0P	3 credits

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Analyse transmission lines and estimate voltage and current at any point on transmission line for different load conditions.
- Provide solution to real life plane wave problems for various boundary conditions.
- Analyse the field equations for the wave propagation in special cases such as lossy and low loss dielectric media.
- Visualize TE and TM mode patterns of field distributions in a rectangular wave-guide.
- Understand and analyse radiation by antennas.

Module 1: Transmission Lines (6 hours)

Introduction, Concept of distributed elements, Equations of voltage andcurrent, Standing waves and impedance transformation, Lossless and low-loss transmission lines, Power transfer on a transmission line, Analysis of transmission line in terms of admittances, Transmission line calculations with the help of Smith chart, Applications of transmission line, Impedance matching using transmission lines.

Module 2: Maxwell's Equations (6 hours)

Basic quantities of Electromagnetics, Basic laws of Electromagnetics: Gauss's law, Ampere's Circuital law, Faraday's law of Electromagnetic induction. Maxwell's equations, Surface charge and surface current, Boundary conditions at media interface.

Module 3: Uniform Plane Wave (7 hours)

Homogeneous unbound medium, Wave equation for time harmonic fields,Solution of the wave equation, Uniform plane wave, Wave polarization, Wave propagation in conducting medium, Phase velocity of a wave, Power flow and Poynting vector.

Module 4: Plane Waves at Media Interface (7 hours)

Plane wave in arbitrary direction, Plane wave at dielectric interface, Reflection and refraction of waves at dielectric interface, Total internal reflection, Wave polarization at media interface, Brewster angle, Fields and power flow at media interface, Lossy media interface, Reflection from conducting boundary.

Module 5: Waveguides (7 hours)

Parallel plane waveguide: Transverse Electric (TE) mode, transverse Magnetic(TM) mode, Cut-off frequency, Phase velocity and dispersion. Transverse Electromagnetic (TEM) mode, Analysis of waveguide-general approach, Rectangular waveguides.

Module 6: Antennas (7 hours)

Radiation parameters of antenna, Potential functions, Solution for potential functions, Radiations from Hertz dipole, Near field, Far field, Total power radiated by a dipole, Radiation resistance and radiation pattern of Hertz dipole, Hertz dipole in receiving mode.

Text/Reference Books

1. R. K. Shevgaonkar, **“**Electromagnetic Waves**”**, Tata McGraw Hill, 2005.
2. D. K. Cheng, “Field and Wave Electromagnetics**”**, Addison-Wesley, 1989.
3. M. N.O. Sadiku, “Elements of Electromagnetics**”**, Oxford University Press, 2007.
4. C. A. Balanis, “Advanced Engineering Electromagnetics”, John Wiley & Sons, 2012.
5. C. A. Balanis, “Antenna Theory: Analysis and Design**”**, John Wiley & Sons, 2005.

PEC-EE17	Computational Electromagnetics	3L:0T:0P	3 credits

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Understand the basic concepts of electromagnetics.
- Understand computational techniques for computing fields.
- Apply the techniques to simple real-life problems.

Module 1: Introduction (6 hours)

Conventional design methodology, Computer aided design aspects – Advantages. Review of basic fundamentals of Electrostatics and Electromagnetics. Development of Helmhotz equation, energy transformer vectors- Poynting and Slepian, magnetic Diffusion-transients and time-harmonic.

Module 2: Analytical Methods (6 hours)

Analytical methods of solving field equations, method of separation of variables, Roth's method, integral methods- Green's function, method of images.

Module 3: Finite Difference Method (FDM) (7 hours)

Finite Difference schemes, treatment of irregular boundaries, accuracy and stability of FD solutions, Finite-Difference Time-Domain (FDTD) method- Uniqueness and convergence.

Module 4: Finite Element Method (FEM) (7 hours)

Overview of FEM, Variational and Galerkin Methods, shape functions, lower and higher order elements, vector elements, 2D and 3D finite elements, efficient finite element computations.

Module 5: Special Topics(7 hours)

{Background of experimental methods-electrolytic tank, R-C network solution, Field plotting (graphical method)}, hybrid methods, coupled circuit - field computations, electromagnetic - thermal and electromagnetic - structural coupled computations, solution of equations, method of moments, Poisson's fields.

Module 6: Applications (7 hours)

Low frequency electrical devices, static / time-harmonic / transient problems in transformers, rotating machines, actuators. CAD packages.

Text/Reference Books

1. P. P. Silvester and R. L. Ferrari "Finite Element for Electrical Engineers", Cambridge University press, 1996.
2. M. N. O. Sadiku, "Numerical Techniques in Electromagnetics", CRC press, 2001.

PEC-EE18	Control Systems Design	3L:0T:0P	3 credits

Course Outcomes: At the end of this course, students will demonstrate the ability to

- Understand various design specifications.
- Design controllers to satisfy the desired design specifications using simple controller structures (P, PI, PID, compensators).
- Design controllers using the state-space approach.

Module 1: Design Specifications (6 hours)
Introduction to design problem and philosophy. Introduction to time domain and frequency domain design specification and its physical relevance. Effect of gain on transient and steady state response. Effect of addition of pole on system performance. Effect of addition of zero on system response.

Module 2: Design of Classical Control System in the time domain (8 hours)
Introduction to compensator. Design of Lag, lead lag-lead compensator in time domain. Feedback and Feed forward compensator design. Feedback compensation. Realization of compensators.

Module 3: Design of Classical Control System in frequency domain (8 hours)
Compensator design in frequency domain to improve steady state and transient response. Feedback and Feed forward compensator design using bode diagram.

Module 4: Design of PID controllers (6 hours)
Design of P, PI, PD and PID controllers in time domain and frequency domain for first, second and third order systems. Control loop with auxiliary feedback – Feed forward control.

Module 5: Control System Design in state space (8 hours)
Review of state space representation. Concept of controllability & observability, effect of pole zero cancellation on the controllability & observability of the system, pole placement design through state feedback. Ackerman's Formula for feedback gain design. Design of Observer. Reduced order observer. Separation Principle.

Module 6: Nonlinearities and its effect on system performance (3 hours)
Various types of non-linearities. Effect of various non-linearities on system performance. Singular points. Phase plot analysis.

Text and Reference Books :

1. N. Nise, “Control system Engineering”, John Wiley, 2000.
2. I. J. Nagrath and M. Gopal, “Control system engineering”, Wiley, 2000.
3. M. Gopal, “Digital Control Engineering”, Wiley Eastern, 1988.
4. K. Ogata, “Modern Control Engineering”, Prentice Hall, 2010.
5. B. C. Kuo, “Automatic Control system”, Prentice Hall, 1995.
6. J. J. D'Azzo and C. H. Houpis, “Linear control system analysis and design (conventional and modern)”, McGraw Hill, 1995.
7. R. T. Stefani and G. H. Hostetter, “Design of feedback Control Systems”, Saunders College Pub, 1994.

PEC-EE19	Advanced Electric Drives	3L:0T:0P	3 credits

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Understand the operation of power electronic converters and their control strategies.
- Understand the vector control strategies for ac motor drives
- Understand the implementation of the control strategies using digital signal processors.

Module 1: Power Converters for AC drives (10 hours)

PWM control of inverter, selected harmonic elimination, space vector modulation, current control of VSI, three level inverter, Different topologies, SVM for 3 level inverter, Diode rectifier with boost chopper, PWM converter as line side rectifier, current fed inverters with self-commutated devices. Control of CSI, H bridge as a 4-Q drive.

Module 2: Induction motor drives (10 hours)

Different transformations and reference frame theory, modeling of induction machines, voltage fed inverter control-v/f control, vector control, direct torque and flux control(DTC).

Module 3: Synchronous motor drives (6 hours)

Modeling of synchronous machines, open loop v/f control, vector control, direct torque control, CSI fed synchronous motor drives.

Module 4: Permanent magnet motor drives (6 hours)

Introduction to various PM motors, BLDC and PMSM drive configuration, comparison, block diagrams, Speed and torque control in BLDC and PMSM.

Module 5: Switched reluctance motor drives (6 hours)

Evolution of switched reluctance motors, various topologies for SRM drives, comparison, Closed loop speed and torque control of SRM.

Module 6: DSP based motion control (6 hours)

Use of DSPs in motion control, various DSPs available, realization of some basic blocks in DSP for implementation of DSP based motion control.

Text / References:

1. B. K. Bose, “Modern Power Electronics and AC Drives”, Pearson Education, Asia, 2003.
2. P. C. Krause, O. Wasynczuk and S. D. Sudhoff, “Analysis of Electric Machinery and Drive Systems”, John Wiley & Sons, 2013.
3. H. A. Taliyat and S. G. Campbell, “DSP based Electromechanical Motion Control”, CRC press, 2003.
4. R. Krishnan, “Permanent Magnet Synchronous and Brushless DC motor Drives”, CRC Press, 2009.

Project/Internship

PROJ-EE01	**Project Work –I**	**0L:0T:6P**	**3 credits**

The object of Project Work I is to enable the student to take up investigative study in the broad field of Electronics & Communication Engineering, either fully theoretical/practical or involving both theoretical and practical work to be assigned by the Department on an individual basis or two/three students in a group, under the guidance of a Supervisor. This is expected to provide a good initiation for the student(s) in R&D work. The assignment to normally include:

1. Survey and study of published literature on the assigned topic;
2. Working out a preliminary Approach to the Problem relating to the assigned topic;
3. Conducting preliminary Analysis/Modelling/Simulation/Experiment/Design/Feasibility;
4. Preparing a Written Report on the Study conducted for presentation to the Department;
5. Final Seminar, as oral Presentation before a departmental committee.

PROJ-EE02	Project Work II & Dissertation	0L:0T:16P	8 credits

The object of Project Work II & Dissertation is to enable the student to extend further the investigative study taken up under EC P1, either fully theoretical/practical or involving both theoretical and practical work, under the guidance of a Supervisor from the Department alone or jointly with a Supervisor drawn from R&D laboratory/Industry. This is expected to provide a good training for the student(s) in R&D work and technical leadership. The assignment to normally include:

1. In depth study of the topic assigned in the light of the Report prepared under EEP1;
2. Review and finalization of the Approach to the Problem relating to the assigned topic;
3. Preparing an Action Plan for conducting the investigation, including team work;
4. Detailed Analysis/Modelling/Simulation/Design/Problem Solving/Experiment as needed;
5. Final development of product/process, testing, results, conclusions and future directions;
6. Preparing a paper for Conference presentation/Publication in Journals, if possible;
7. Preparing a Dissertation in the standard format for being evaluated by the Department.
8. Final Seminar Presentation before a Departmental Committee.

PROJ-EE	**Summer Industry Internship**

Minimum of six weeks in an Industry in the area of Electrical Engineering. The summer internship should give exposure to the practical aspects of the discipline. In addition, the student may also work on a specified task or project which may be assigned to him/her. The outcome of the internship should be presented in the form of a report.

MODEL CURRICULUM

for

UNDERGRADUATE DEGREE COURSES
IN

MECHANICAL ENGINEERING

(Engineering & Technology)

[January 2018]

ALL INDIA COUNCIL FOR TECHNICAL EDUCATION
Nelson Mandela Marg, Vasant Kunj, New Delhi 110 070
www.aicte-india.org

All India Council for Technical Education
Model curriculum for
Undergraduate Degree Courses in Engineering & Technology

MECHANICAL ENGINEERING

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		PCC-ME 305: Mechanical Engineering Laboratory (Thermal) I
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		PCC-ME 307: Manufacturing Technology
		PCC-ME 308: Design of Machine Elements
		PCC-ME 309: Mechanical Engineering Laboratory (Design) II
		PROJ -ME 310: Project II
		PCC-ME401: Automation in manufacturing
		ME402: Mechanical Engineering Laboratory III (Manufacturing)

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		PEC-MEL 422: Finite Element Analysis
		PEC-MEL 423: Power Plant Engineering
		PEC-MEL 424: Gas Dynamics and Jet Propulsion
		PEC-MEL 425: Process Planning and Cost Estimation
		PEC-MEL 431: Principles of Management
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All India Council for Technical Education
Model curriculum for
Undergraduate Degree Courses in Engineering & Technology

MECHANICAL ENGINEERING

Chapter -1

General, Course structure & Theme
&
Semester-wise credit distribution

A. Definition of Credit:

1 Hr. Lecture (L) per week	1 credit
1 Hr. Tutorial (T) per week	1 credit
1 Hr. Practical (P) per week	0.5 credits
2 Hours Practical(Lab)/week	1 credit

B. Range of credits -A range of credits from 150 to 160 for a student to be eligible to get Under Graduate degree in Engineering. A student will be eligible to get Under Graduate degree with Honours or additional Minor Engineering, if he/she completes an additional 20 credits. These could be acquired through MOOCs.

C. Structure of Undergraduate Engineering program :

S. No.	Category	Suggested Breakup of Credits (Total 160)
1	Humanities and Social Sciences including Management courses	12*
2	Basic Science courses	25*
3	Engineering Science courses including workshop, drawing, basics of electrical/mechanical/computer etc	24*
4	Professional core courses	48*
5	Professional Elective courses relevant to chosen specialization/branch	18*
6	Open subjects – Electives from other technical and /or emerging subjects	18*
7	Project work, seminar and internship in industry or elsewhere	15*
8	Mandatory Courses [Environmental Sciences, Induction Program, Indian Constitution, Essence of Indian Traditional Knowledge]	(non-credit)
	Total	160*

**Minor variation is allowed as per need of the respective disciplines.*

D. Credit distribution in the First year of Undergraduate Engineering program :

	Lecture	Tutorial	Laboratory/Practical	Total credits
Chemistry –I	3	1	3	5.5
Physics	3	1	3	5.5
Maths-1	3	1	0	4
Maths -2	3	1	0	4
Programming for Problem solving	3	0	4	5
English	2	0	2	3
Engineering Graphics &Design	1	0	4	3
Workshop/ Practicals	1	0	4	3
Basic Electrical Engg.	3	1	2	5
*Biology	2	1	0	3
*Engg. Mechanics	3	1	0	4
*Maths-3	3	1	0	4

**These courses may be offered preferably in the 3rd semester & onwards.*

E. Course code and definition:

Course code	Definitions
BSC	Basic Science Courses
ESC	Engineering Science Courses
HSMC	Humanities and Social Sciences including Management courses
PCC	Professional core courses
PEC	Professional Elective courses
OEC	Open Elective courses
LC	Laboratory course
MC	Mandatory courses

BASIC SCIENCE COURSES

Sl. No	Code No.	Subject	Semester	Credits
1	BSC 101	Physics I (Electromagnetism)	I	5.5
2	BSC 201	Physics II (Optics & waves)	III	4
2	BSC 102	Mathematics I (Calculus & Linear Algebra)	I	4
3	BSC 103	Chemistry	II	5.5
4	BSC 104	Mathematics II (ODE, Complex variables)	II	4
5	BSC 202	Mathematics III (PDE, Prob/Stat)	III	4
6	BSC 203	Biology	III	3
			Total Credits:	**30**

ENGINEERING SCIENCE COURSES

Sl. No	Code No.	Subject	Semester	Credits
1	ESC 101	Basic Electrical Engineering	I	5
2	ESC 102	Engineering Graphics& Design	I	3
3	ESC 103	Programming for Problem Solving	II	5
4	ESC 104	Workshop /Manufacturing Practice	II	3
5	ESC 201	Basic Electronic Engineering	III	4
6	ESC 202	Engineering Mechanics	III	4
			Total Credits:	**24**

HUMANITIES & SOCIAL SCIENCES INCLUDING MANAGEMENT COURSES

Sl. No	Code No.	Subject	Semester	Credits
1	HSMC 01	English	I	3
2	HSMC 03	Industrial Psychology	----	3
3	HSMC 04	Operations Research	----	3
4	HSMC 05	Economics	----	3
5	HSMC 06	Finance & Accounting	----	3
6				
7				
			Total Credits:	

PROFESSIONAL CORE COURSES

Sl. No	Code No.	Subject	Semester	Credits
1	PCC- ME 201	Thermodynamics	3	4
2	PCC- ME 202	Applied Thermodynamics	4	4
3	PCC- ME 203	Fluid Mechanics & Fluid Machines	4	4
4	PCC- ME 204	Strength of Materials	4	4
5	PCC- ME 205	Material Engineering	4	4
6	PCC- ME 206	Instrumentation & Control	4	4
7	PCC- ME 301	Heat Transfer	5	4
8	PCC- ME 302	Solid Mechanics	5	4
9	PCC- ME 303	Manufacturing Processes	5	3
10	PCC- ME 304	Kinematics & Theory of Machines	5	4
11	PCC- ME 305	Mechanical Engineering Laboratory (Thermal)- I	5	1.5
12	PCC- ME 306	Manufacturing Technology	6	4
13	PCC- ME 307	Design of Machine Elements	6	4
14	PCC- ME 308	Mechanical Engineering Laboratory (Design) II	6	1.5
15	PCC- ME 401	Automation in manufacturing	7	3
			Total Credits:	**53**

PROFESSIONAL ELECTIVE COURSES

Sl. No	Code No.	Subject	Semester	Credits
1	PEC –MEL321	Internal Combustion Engines	VI	3-0-0-3
2	PEC- MEL 322	Mechatronic systems	VI	3-0-0-3
3	PEC- ME 421	Refrigeration &Air-conditioning	VII	3-0-0-3
4	PEC- MEL 422	Finite Element Analysis	VII	3-0-0-3
5				
6				
7				

Total Credits:	**18**

OPEN ELECTIVE COURSES [SAMPLE]

Sl. No	**Code No.**	**Subject**	**Semester**	**Credits**
1	OEC - ME201	Nanotechnology and Surface Engineering	VII	3-0-0-3
2				
3				
4				
			Total Credits:	**18 (incl HSMC)**

4 year Curriculum structure
Undergraduate Degree in Engineering & Technology

Branch / course: Mechanical Engineering
Total credits (4 year course)158.5

I. Induction Program(Please refer **Appendix-A** for guidelines. Details of Induction program also available in the curriculum of Mandatory courses.)

Induction program (mandatory)	**3 weeks duration** (Please refer Appendix-A for guidelines & also details available in the curriculum of Mandatory courses)
Induction program for students to be offered right at the start of the first year.	• Physical activity • Creative Arts • Universal Human Values • Literary • Proficiency Modules • Lectures by Eminent People • Visits to local Areas • Familiarization to Dept./Branch & Innovations

II. Semester-wise structure of curriculum

[L= Lecture, T = Tutorials, P = Practicals& C = Credits]

Semester I (First year]
Branch/Course Mechanical Engineering

Sl. No.	Category	Course Code	Course Title	Hours per week			Total contact hours	Credits
				Lecture	Tutorial	Practical		
1.	Basic Science course	BSC101	Physics –I (Electromagnetism)	3	1	3	7	5.5
2.	Basic Science course	BSC102	Mathematics –I (Calculus & Linear Algebra)	3	1	0	4	4
3.	Engineering Science Courses	ESC101	Basic Electrical Engineering	3	1	2	6	5
4.	Engineering Science Courses	ESC102	Engineering Graphics& Design	1	0	4	5	3
							Total credits	**17.5**

Semester II (First year]
Branch/Course Mechanical Engineering

Sl. No.	Category	Code	Course Title	Hours per week			Total contact hours	Credits
				Lecture	Tutorial	Practical		
1	Basic Science Courses	BSC103	Chemistry-I	3	1	3	7	5.5
2	Basic Science courses	BSC104	Mathematics –II (ODE& Complex Variables)	3	1	0	4	4
3	Engineering Science Courses	ESC103	Programming for Problem Solving	3	0	4	7	5
4	Engineering Science Courses	ESC104	Workshop/Manufacturing Practices	1	0	4	5	3
5.	Humanities and Social Sciences including Management courses	HSMC 101	English	2	0	2	4	3
6	Mandatory Courses	MC-I	Constitution of India	-	-	-	-	0
							Total credits	**20.5**

Semester III (Second year]
Branch/Course Mechanical Engineering

Sl. No.	Category	Code	Course Title	Hours per week			Total contact hours	Credits
				Lecture	Tutorial	Practical		
1	Basic Science Courses	BSC- 201	Physics II (Optics & Waves)	3	1	0	4	4
2	Basic Science Courses	BSC- 202	Mathematics III (PDE, Probability & Statistics)	3	1	0	4	4
3	Basic Science Courses	BSC- 203	Biology	3	0	0	3	3
4	Engineering Science courses	ESC- 201	Basic Electronics Engineering	3	1	0	4	4
5	Engineering Science courses	ESC- 202	Engineering Mechanics	3	1	0	4	4
6	Professional Core courses	PCC- ME 201	Thermodynamics	3	1	0	4	4
							Total credits	**23**

Semester IV (Second year]
Branch/Course Mechanical Engineering

Sl. No.	Category	Code	Course Title	Hours per week			Total contact hours	Credits
				Lecture	Tutorial	Practical		
1	Professional Core courses	PCC-ME 202	Applied Thermodynamics	3	1	0	4	4
2	Professional Core courses	PCC-ME 203	Fluid Mechanics & Fluid Machines	3	1	0	4	4
3	Professional Core courses	PCC-ME 204	Strength of Materials	3	1	0	4	4
4	Engineering Science courses	PCC-ME 205	Materials Engineering	3	0	0	3	3
5	Professional Core courses	PCC-ME 206	Instrumentation & Control	3	1	0	4	4
6	Mandatory courses	MC-II	Environmental Science	-	-	-	-	0
			Total credits					**19**

Semester V (Third year]
Branch/Course Mechanical Engineering

Sl. No.	Category	Code	Course Title	Hours per week			Total contact hours	Credits
				Lecture	Tutorial	Practical		
1	Professional Core courses	PCC- ME 301	Heat Transfer	3	1	0		4
2	Professional Core courses	PCC- ME 302	Solid Mechanics	3	1	0		4
3	Professional Core courses	PCC- ME 303	Manufacturing Processes	3	0	0		3
4	Professional Core courses	PCC- ME 304	Kinematics & Theory of Machines	3	1	0		4
5	Humanities and Social Sciences including Management courses	HSMC301 (OEL I)	Humanities I	3	0	0		3
6	Professional Core courses	PCC- ME 305	Mechanical Engineering Laboratory (Thermal) I	0	0	3		1.5
7	Mandatory course	MC – III	Essence of Indian Traditional Knowledge	0	0	0		0
8	Project (Summer internship)	PROJ- ME 306	Project-I	0	0	2	(30 hrs Total)	1
			Total credits					**20.5**

Semester VI (Third year]
Branch/Course Mechanical Engineering

Sl. No.	Category	Code	Course Title	Hours per week			Total contact hours	Credits
				Lecture	Tutorial	Practical		
1	Professional Core courses	PCC-ME 307	Manufacturing Technology	4	0	0		4
2	Professional Core courses	PCC-ME 308	Design of Machine Elements	3	1	0		4
3	Professional Elective courses	PEC-MEL321 - 325	Elective-I	3	0	0		3
4	Professional Elective courses	PEC-MEL321 - 325	Elective-II	3	0	0		3
5	Humanities and Social Sciences including Management	OEC302	Open Elective-II (Humanities)	3	0	0		3
6	Professional Core courses	PCC-ME 309	Mechanical Engineering Laboratory (Design) II	0	0	3		1.5
7	Project (Or Summer internship)	PROJ-ME 310	Project-II	0	0	6	(90 hrs Total)	3
			Total credits					**21.5**

Semester VII (Fourth year]
Branch/Course: Mechanical Engineering

Sl. No.	Category	Code	Course Title	Hours per week			Total contact hours	Credits
				Lecture	Tutorial	Practical		
1	Professional Core courses	PCC- ME 401	Automation in Manufacturing	3	0	0		3
2	Professional Elective courses	PEC-MEL421–425	Elective III	3	0	0		3
3	Professional Elective courses	PEC-MEL 421 - 425	Elective-IV	3	0	0		3
4	Open Elective courses	OEC401	Open Elective-III	3	0	0		3
5	Professional Core courses	PCC-ME 402	Mechanical Engineering Laboratory III (Manufacturing)	0	0	3		1.5
5	Project	PROJ-ME 403	Project-III	0	0	10		5
							Total credits	**18.5**

Semester VIII (Fourth year]
Branch/Course Mechanical Engineering

Sl. No.	Category	Code	Course Title	Hours per week			Total contact hours	Credits
				Lecture	Tutorial	Practical		
1	Professional Elective Courses	PEC-MEL431– 435	Elective V	3	0	0		3
2	Professional Elective Courses	PEC-MEL431 - 435	Elective VI	3	0	0		3
3	Open Elective courses	OEC- 402	Open Elective-IV	3	0	0		3
4	Open Elective courses	OEC- 403	Open Elective-V	3	0	0		3
5	Project	PROJ-ME 404	Project-IV	0	0	12		6
							Total credits	**18**

TOTAL CREDITS – 158.5

CHAPTER 2

DETAILED 4-YEAR CURRICULUM CONTENTS

Undergraduate Degree in Engineering & Technology

Branch/Course: MECHANICAL ENGINEERING

BASIC SCIENCE COURSES

BSC102	MATHEMATICS 1 (Calculus and Linear Algebra)	3L:1T:0P	4 credits

Contents

Module 1: Calculus: (6 lectures)
Evolutes and involutes; Evaluation of definite and improper integrals; Beta and Gamma functions and their properties; Applications of definite integrals to evaluate surface areas and volumes of revolutions.

Module 2: Calculus: (6 lectures)
Rolle's Theorem, Mean value theorems, Taylor's and Maclaurin theorems with remainders; indeterminate forms and L'Hospital's rule; Maxima and minima.

Module 3: Sequences and series: (10 lectures)
Convergence of sequence and series, tests for convergence; Power series, Taylor's series, series for exponential, trigonometric and logarithm functions; Fourier series: Half range sine and cosine series, Parseval's theorem.

Module 4: Multivariable Calculus (Differentiation): (8 lectures)
Limit, continuity and partial derivatives, directional derivatives, total derivative; Tangent plane and normal line; Maxima, minima and saddle points; Method of Lagrange multipliers; Gradient, curl and divergence.

Module 5: Matrices (10 lectures)
Inverse and rank of a matrix, rank-nullity theorem; System of linear equations; Symmetric, skew-symmetric and orthogonal matrices; Determinants; Eigenvalues and eigenvectors; Diagonalization of matrices; Cayley-Hamilton Theorem, and Orthogonal transformation.

Suggested Text/Reference Books

(i) G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Edition, Pearson, Reprint, 2002.
(ii) Erwin kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
(iii) Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.
(iv) Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11th Reprint, 2010.
(v) D. Poole, Linear Algebra: A Modern Introduction, 2nd Edition, Brooks/Cole, 2005.
(vi) N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2008.
(vii) B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36th Edition, 2010.

Course Outcomes

The objective of this course is to familiarize the prospective engineers with techniques in calculus, multivariate analysis and linear algebra. It aims to equip the students with standard concepts and tools at an intermediate to advanced level that will serve them well towards

tackling more advanced level of mathematics and applications that they would find useful in their disciplines.
The students will learn:

- To apply differential and integral calculus to notions of curvature and to improper integrals. Apart from some other applications they will have a basic understanding of Beta and Gamma functions.
- The fallouts of Rolle's Theorem that is fundamental to application of analysis to Engineering problems.
- The tool of power series and Fourier series for learning advanced Engineering Mathematics.
- To deal with functions of several variables that are essential in most branches of engineering.
- The essential tool of matrices and linear algebra in a comprehensive manner.

BSC104	**MATHEMATICS I1 (Calculus, Ordinary Differential Equations and Complex Variable)**	**3L:1T:0P**	**4 credits**

Detailed contents
Module 1: Multivariable Calculus (Integration): (10 lectures)
Multiple Integration: Double integrals (Cartesian), change of order of integration in double integrals, Change of variables (Cartesian to polar), Applications: areas and volumes, Center of mass and Gravity (constant and variable densities); Triple integrals (Cartesian), orthogonal curvilinear coordinates, Simple applications involving cubes, sphere and rectangular parallelepipeds; Scalar line integrals, vector line integrals, scalar surface integrals, vector surface integrals, Theorems of Green, Gauss and Stokes.

Module 2: First order ordinary differential equations: (6 lectures)
Exact, linear and Bernoulli's equations, Euler's equations, Equations not of first degree: equations solvable for p, equations solvable for y, equations solvable for x and Clairaut's type.

Module 3: Ordinary differential equations of higher orders: (8 lectures)
Second order linear differential equations with variable coefficients, method of variation of parameters, Cauchy-Euler equation; Power series solutions; Legendre polynomials, Bessel functions of the first kind and their properties.

Module 4: Complex Variable – Differentiation: (8 lectures)
Differentiation, Cauchy-Riemann equations, analytic functions, harmonic functions, finding harmonic conjugate; elementary analytic functions (exponential, trigonometric, logarithm) and their properties; Conformal mappings, Mobius transformations and their properties.

Module 5: Complex Variable – Integration: (8 lectures)

Contour integrals, Cauchy-Goursat theorem (without proof), Cauchy Integral formula (without proof), Liouville's theorem and Maximum-Modulus theorem (without proof); Taylor's series, zeros of analytic functions, singularities, Laurent's series; Residues, Cauchy Residue theorem (without proof), Evaluation of definite integral involving sine and cosine, Evaluation of certain improper integrals using the Bromwich contour.

Suggested Text/Reference Books

(i) G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Edition, Pearson, Reprint, 2002.
(ii) Erwin kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
(iii) W. E. Boyce and R. C. DiPrima, Elementary Differential Equations and Boundary Value Problems, 9th Edn., Wiley India, 2009.
(iv) S. L. Ross, Differential Equations, 3rd Ed., Wiley India, 1984.
(v) E. A. Coddington, An Introduction to Ordinary Differential Equations, Prentice Hall India, 1995.
(vi) E. L. Ince, Ordinary Differential Equations, Dover Publications, 1958.
(vii) J. W. Brown and R. V. Churchill, Complex Variables and Applications, 7th Ed., Mc-Graw Hill, 2004.
(viii) N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2008.
(ix) B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36th Edition, 2010.

Course Outcomes

The objective of this course is to familiarize the prospective engineers with techniques in multivariate integration, ordinary and partial differential equations and complex variables. It aims to equip the students to deal with advanced level of mathematics and applications that would be essential for their disciplines.

The students will learn:

- The mathematical tools needed in evaluating multiple integrals and their usage.
- The effective mathematical tools for the solutions of differential equations that model physical processes.
- The tools of differentiation and integration of functions of a complex variable that are used in various techniques dealing engineering problems.

BSC202	Mathematics III (PDE, Probability & Statistics)	3L:1T:0P	4 credits

Objectives:

(1) To introduce the solution methodologies for second order Partial Differential Equations with applications in engineering
(2) To provide an overview of probability and statistics to engineers

Contents:

Definition of Partial Differential Equations, First order partial differential equations, solutions of first order linear PDEs; Solution to homogenous and non-homogenous linear partial differential equations of second order by complimentary function and particular integral method. Second-order linear equations and their classification, Initial and boundary conditions, D'Alembert's solution of the wave equation; Duhamel's principle for one dimensional wave equation. Heat diffusion and vibration problems, Separation of variables method to simple problems in Cartesian coordinates. The Laplacian in plane, cylindrical and spherical polar coordinates, solutions with Bessel functions and Legendre functions. One dimensional diffusion equation and its solution by separation of variables. **(14 hours)**

Probability spaces, conditional probability, independence; Discrete random variables, Independent random variables, the multinomial distribution, Poisson approximation to the binomial distribution, infinite sequences of Bernoulli trials, sums of independent random variables; Expectation of Discrete Random Variables, Moments, Variance of a sum, Correlation coefficient, Chebyshev's Inequality. Continuous random varibales and their properties, distribution functions and densities, normal, exponential and gamma densities.Bivariate distributions and their properties, distribution of sums and quotients, conditional densities, Bayes' rule.**(12 hours)**

Basic Statistics, Measures of Central tendency: Moments, skewness and Kurtosis - Probability distributions: Binomial, Poisson and Normal - evaluation of statistical parameters for these three distributions, Correlation and regression – Rank correlation. Curve fitting by the method of least squares- fitting of straight lines, second degree parabolas and more general curves. Test of significance: Large sample test for single proportion, difference of proportions, Tests for single mean, difference of means, and difference of standard deviations. Test for ratio of variances - Chi-square test for goodness of fit and independence of attributes.**(12 hours)**

Course Outcomes:

Upon completion of this course, students will be able to solve field problems in engineering involving PDEs. They can also formulate and solve problems involving random variables and apply statistical methods for analysing experimental data.

Textbooks/References:

1. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
2. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2010.
3. P. G. Hoel, S. C. Port and C. J. Stone, Introduction to Probability Theory, Universal Book Stall, 2003 (Reprint).
4. S. Ross, A First Course in Probability, 6th Ed., Pearson Education India, 2002.

ENGINEERING SCIENCE COURSES

ESC 201	Basic Electronic Engineering	3L:1T:0P	4 credits

Objectives:
To provide an overview of electronic device components to Mechanical engineering students

Contents
Semiconductor Devices and Applications: Introduction to P-N junction Diode and V-I characteristics, Half wave and Full-wave rectifiers, capacitor filter. Zener diode and its characteristics, Zener diode as voltage regulator. Regulated power supply IC based on 78XX and 79XX series, Introduction to BJT, its input-output and transfer characteristics, BJT as a single stage CE amplifier, frequency response and bandwidth.

Operational amplifier and its applications: Introduction to operational amplifiers, Op-amp input modes and parameters, Op-amp in open loop configuration, op-amp with negative feedback, study of practical op-amp IC 741, inverting and non-inverting amplifier applications: summing and difference amplifier, unity gain buffer, comparator, integrator and differentiator.

Timing Circuits and Oscillators: RC-timing circuits, IC 555 and its applications as astable and mono-stable multi-vibrators, positive feedback, Barkhausen's criteria for oscillation, R-C phase shift and Wein bridge oscillator.

Digital Electronics Fundamentals :Difference between analog and digital signals, Boolean algebra, Basic and Universal Gates, Symbols, Truth tables, logic expressions, Logic simplification using K- map, Logic ICs, half and full adder/subtractor, multiplexers, de-multiplexers, flip-flops, shift registers, counters, Block diagram of microprocessor/microcontroller and their applications.

Electronic Communication Systems: The elements of communication system, IEEE frequency spectrum, Transmission media: wired and wireless, need of modulation, AM and FM modulation schemes, Mobile communication systems: cellular concept and block diagram of GSM system.

Text /Reference Books:
1. Floyd ,” Electronic Devices” Pearson Education 9th edition, 2012.
2. R.P. Jain , “Modern Digital Electronics”, Tata Mc Graw Hill, 3rd Edition, 2007.
3. Frenzel, “Communication Electronics: Principles and Applications”, Tata Mc Graw Hill, 3rd Edition, 2001

Course Outcomes:
At the end of this course students will demonstrate the ability to
1. Understand the principles of semiconductor devices and their applications.
2. Design an application using Operational amplifier.
3. Understand the working of timing circuits and oscillators.
4. Understand logic gates, flip flop as a building block of digital systems.
5. Learn the basics of Electronic communication system.

PROFESSIONAL CORE COURSES

PCC-ME 201	**Thermodynamics**	**3L:0T:1P**	**4 credits**

Objectives:

- To learn about work and heat interactions, and balance of energy between system and its surroundings
- To learn about application of I law to various energy conversion devices
- To evaluate the changes in properties of substances in various processes
- To understand the difference between high grade and low grade energies and II law limitations on energy conversion

Contents:

Fundamentals - System & Control volume; Property, State & Process; Exact & Inexact differentials; Work - Thermodynamic definition of work; examples; Displacement work; Path dependence of displacement work and illustrations for simple processes; electrical, magnetic, gravitational, spring and shaft work. **(5)**

Temperature, Definition of thermal equilibrium and Zeroth law; Temperature scales; Various Thermometers- Definition of heat; examples of heat/work interaction in systems- First Law for Cyclic & Non-cyclic processes; Concept of total energy E ; Demonstration that E is a property; Various modes of energy, Internal energy and Enthalpy. **(5)**

Definition of Pure substance, Ideal Gases and ideal gas mixtures, Real gases and real gas mixtures, Compressibility charts- Properties of two phase systems - Const. temperature and Const. pressure heating of water; Definitions of saturated states; P-v-T surface; Use of steam tables and R134a tables; Saturation tables; Superheated tables; Identification of states & determination of properties, Mollier's chart. **(8)**

First Law for Flow Processes - Derivation of general energy equation for a control volume; Steady state steady flow processes including throttling; Examples of steady flow devices; Unsteady processes; examples of steady and unsteady I law applications for system and control volume. **(5)**

Second law - Definitions of direct and reverse heat engines; Definitions of thermal efficiency and COP; Kelvin-Planck and Clausius statements; Definition of reversible process; Internal and external irreversibility; Carnot cycle; Absolute temperature scale. **(5)**

Clausius inequality; Definition of entropy S ; Demonstration that entropy S is a property; Evaluation of S for solids, liquids, ideal gases and ideal gas mixtures undergoing various processes; Determination of s from steam tables- Principle of increase of entropy; Illustration of processes in T-s coordinates; Definition of Isentropic efficiency for compressors, turbines and nozzles- Irreversibility and Availability, Availability function for systems and Control volumes undergoing different processes, Lost work. Second law analysis for a control volume. Exergy balance equation and Exergy analysis.**(8)**

Thermodynamic cycles - Basic Rankine cycle; Basic Brayton cycle; Basic vapor compression cycle and comparison with Carnot cycle. **(4)**

Total Hours (40 lectures + 12 tutorials)

Course Outcomes:

1. After completing this course, the students will be able to apply energy balance to systems and control volumes, in situations involving heat and work interactions
2. Students can evaluate changes in thermodynamic properties of substances
3. The students will be able to evaluate the performance of energy conversion devices
4. The students will be able to differentiate between high grade and low grade energies.

Text Books:

1. Sonntag, R. E, Borgnakke, C. and Van Wylen, G. J., 2003, 6th Edition, *Fundamentals of Thermodynamics*, John Wiley and Sons.
2. Jones, J. B. and Duggan, R. E., 1996, *Engineering Thermodynamics*, Prentice-Hall of India
3. Moran, M. J. and Shapiro, H. N., 1999, *Fundamentals of Engineering Thermodynamics*, John Wiley and Sons.
4. Nag, P.K, 1995, *Engineering Thermodynamics*, Tata McGraw-Hill Publishing Co. Ltd.

PCC-ME 202	Applied Thermodynamics	3L:1T:0P	4 credits

Objectives:

(1)To learn about of I law for reacting systems and heating value of fuels
(2)To learn about gas and vapor cycles and their first law and second law efficiencies
(3) To understand about the properties of dry and wet air and the principles of psychrometry
(4) To learn about gas dynamics of air flow and steam through nozzles
(5) To learn the about reciprocating compressors with and without intercooling
(6) To analyze the performance of steam turbines

Contents:.

Introduction to solid, liquid and gaseous fuels– Stoichiometry, exhaust gas analysis- First law analysis of combustion reactions- Heat calculations using enthalpy tables- Adiabatic flame temperature- Chemical equilibrium and equilibrium composition calculations using free energy.**(8)**

Vapor power cycles Rankine cycle with superheat, reheat and regeneration,exergy analysis. Super-critical and ultra super-critical Rankine cycle- Gas power cycles, Air standard Otto, Diesel and Dual cycles-Air standard Brayton cycle,effect of reheat, regeneration and intercooling- Combined gas and vapor power cycles- Vapor compression refrigeration cycles, refrigerants and their properties.**(12)**

Properties of dry and wet air,use of pschyrometric chart, processes involving heating/cooling and humidification/dehumidification, dew point. **(4)**

Basicsof compressible flow. Stagnation properties, Isentropic flow of a perfect gas through a nozzle, choked flow, subsonic and supersonic flows- normal shocks- use of ideal gas tables for isentropic flow and normal shock flow- Flow of steam and refrigerant through nozzle,supersaturation- compressible flow in diffusers, efficiency of nozzle and diffuser. **(8)**

Reciprocating compressors, staging of reciprocating compressors, optimal stage pressure ratio, effect of intercooling, minimum work for multistage reciprocating compressors. **(5)**

Analysis of steam turbines, velocity and pressure compounding of steam turbines **(3)**
Total number of hours (40 lecture hours + 12 tutorials)

Outcomes:
1. After completing this course, the students will get a good understanding of various practical power cycles and heat pump cycles.
2. They will be able to analyze energy conversion in various thermal devices such as combustors, air coolers, nozzles, diffusers, steam turbines and reciprocating compressors
3. They will be able to understand phenomena occurring in high speed compressible flows

Text Books:
1. Sonntag, R. E, Borgnakke, C. and Van Wylen, G. J., 2003, 6th Edition, *Fundamentals of Thermodynamics*, John Wiley and Sons.
2. Jones, J. B. and Duggan, R. E., 1996, *Engineering Thermodynamics*, Prentice-Hall of India
3. Moran, M. J. and Shapiro, H. N., 1999, *Fundamentals of Engineering Thermodynamics*, John Wiley and Sons.
4. Nag, P.K, 1995, *Engineering Thermodynamics*, Tata McGraw-Hill Publishing Co. Ltd

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PCC-ME 203	**Fluid Mechanics And Fluid Machines**	**3L:1T:0P**	**4 credits**

Objectives:
- To learn about the application of mass and momentum conservation laws for fluid flows
- To understand the importance of dimensional analysis
- To obtain the velocity and pressure variations in various types of simple flows
- To analyze the flow in water pumps and turbines.

Contents :
Definition of fluid, Newton’s law of viscosity, Units and dimensions-Properties of fluids, mass density, specific volume, specific gravity, viscosity, compressibility and surface tension, Control volume- application of continuity equation and momentum equation, Incompressible flow, Bernoulli’s equation and its applications.**(9)**

Exact flow solutions in channels and ducts, Couette and Poisuielle flow, laminar flow through circular conduits and circular annuli- concept of boundary layer – measures of boundary layer thickness – Darcy Weisbach equation, friction factor, Moody’s diagram. **(9)**

Need for dimensional analysis – methods of dimension analysis – Similitude – types of similitude Dimensionless parameters – application of dimensionless parameters – Model analysis. **(6)**

Euler's equation – theory of Rotodynamic machines – various efficiencies – velocity components at entry and exit of the rotor, velocity triangles – Centrifugal pumps, working principle, work done by the impeller, performance curves – Cavitation in pumps- Reciprocating pump – working principle. **(8)**

Classification of water turbines, heads and efficiencies, velocity triangles- Axial, radial and mixed flow turbines- Pelton wheel, Francis turbine and Kaplan turbines, working principles – draft tube- Specific speed, unit quantities, performance curves for turbines – governing of turbines. **(8)**

Course Outcomes:

- Upon completion of this course, students will be able to mathematically analyze simple flow situations
- They will be able to evaluate the performance of pumps and turbines.

PCC-ME 204	Strength of Materials	3L:1T:0P	4 credits

Objectives:

- To understand the nature of stresses developed in simple geometries such as bars, cantilevers, beams, shafts, cylinders and spheres for various types of simple loads
- To calculate the elastic deformation occurring in various simple geometries for different types of loading

Contents :

Deformation in solids- Hooke's law, stress and strain- tension, compression and shear stresses- elastic constants and their relations- volumetric, linear and shear strains- principal stresses and principal planes- Mohr's circle. **(8)**

Beams and types transverse loading on beams- shear force and bend moment diagrams- Types of beam supports, simply supported and over-hanging beams, cantilevers. Theory of bending of beams, bending stress distribution and neutral axis, shear stress distribution, point and distributed loads. **(8)**

Moment of inertia about an axis and polar moment of inertia, deflection of a beam using double integration method, computation of slopes and deflection in beams, Maxwell's reciprocal theorems.**(8)**

Torsion, stresses and deformation in circular and hollow shafts, stepped shafts, deflection of shafts fixed at both ends, stresses and deflection of helical springs. (**8)**

Axial and hoop stresses in cylinders subjected to internal pressure, deformation of thick and thin cylinders, deformation in spherical shells subjected to internal pressure **(8)**

(Total: 40 lectures + 12 tutorials)

Course Outcomes:
- After completing this course, the students should be able to recognise various types loads applied on machine components of simple geometry and understand the nature of internal stresses that will develop within the components
- The students will be able to evaluate the strains and deformation that will result due to the elastic stresses developed within the materials for simple types of loading

Text Books:
1. Egor P. Popov, Engineering Mechanics of Solids, Prentice Hall of India, New Delhi, 2001.
2. R. Subramanian, Strength of Materials, Oxford University Press, 2007.
3. Ferdinand P. Been, Russel Johnson Jr and John J. Dewole, Mechanics of Materials, Tata McGrawHill Publishing Co. Ltd., New Delhi 2005.

PCC-ME 205	**Materials Engineering**	**3L:0T:0P**	**3 credits**

Objectives:
1. Understanding of the correlation between the internal structure of materials, their mechanical properties and various methods to quantify their mechanical integrity and failure criteria.
2. To provide a detailed interpretation of equilibrium phase diagrams
3. Learning about different phases and heat treatment methods to tailor the properties of Fe-C alloys.

Course Contents:

Crystal Structure: Unit cells, Metallic crystal structures, Ceramics. Imperfection in solids: Point, line, interfacial and volume defects; dislocation strengthening mechanisms and slip systems, critically resolved shear stress. **(6)**

Mechanical Property measurement: Tensile, compression and torsion tests; Young's modulus, relations between true and engineering stress-strain curves, generalized Hooke's law, yielding and yield strength, ductility, resilience, toughness and elastic recovery; Hardness: Rockwell, Brinell and Vickers and their relation to strength. **(6)**

Static failure theories: Ductile and brittle failure mechanisms, Tresca, Von-mises, Maximum normal stress, Mohr-Coulomb and Modified Mohr-Coulomb; Fracture mechanics: Introduction to Stress-intensity factor approach and Griffith criterion. Fatigue failure: High cycle fatigue, Stress-life approach, SN curve, endurance and fatigue limits, effects of mean stress using the Modified Goodman diagram; Fracture with fatigue, Introduction to non-destructive testing (NDT) **(8)**

Alloys, substitutional and interstitial solid solutions- Phase diagrams: Interpretation of binary phase diagrams and microstructure development; eutectic, peritectic, peritectoid and monotectic reactions. Iron Iron-carbide phase diagram and microstrctural aspects of ledeburite, austenite, ferrite and cementite, cast iron.**(6)**

Heat treatment of Steel: Annealing, tempering, normalising and spheroidising, isothermal transformation diagrams for Fe-C alloys and microstructure development. Continuous cooling curves and interpretation of final microstructures and properties- austempering, martempering, case hardening, carburizing, nitriding, cyaniding, carbo-nitriding, flame and induction hardening, vacuum and plasma hardening **(6)**

Alloying of steel, properties of stainless steel and tool steels, maraging steels- cast irons; grey, white, malleable and spheroidal cast irons- copper and copper alloys; brass, bronze and cupro-nickel; Aluminium and Al-Cu – Mg alloys- Nickel based superalloys and Titanium alloys **(8)**

Course Outcomes:

1. Student will be able to identify crystal structures for various materials and understand the defects in such structures
2. Understand how to tailor material properties of ferrous and non-ferrous alloys
3. How to quantify mechanical integrity and failure in materials

Text Books:

1. W. D. Callister, 2006, "Materials Science and Engineering-An Introduction", 6th Edition, Wiley India.
2. Kenneth G. Budinski and Michael K. Budinski, "Engineering Materials", Prentice Hall of India Private Limited, 4^{th} Indian Reprint, 2002.
3. V. Raghavan, "Material Science and Engineering', Prentice Hall of India Private Limited, 1999.
4. U. C. Jindal, "Engineering Materials and Metallurgy", Pearson, 2011.

PCC-ME 206	Instrumentation and Control	3L:1T:0P	4 credits

Objectives:

1. To provide a basic knowledge about measurement systems and their components
2. To learn about various sensors used for measurement of mechanical quantities
3. To learn about system stability and control
4. To integrate the measurement systems with the process for process monitoring and control

Contents:

Measurement systems and performance – accuracy, range, resolution, error sources; Instrumentation system elements – sensors for common engineering measurements; Signal processing and conditioning; correction elements- actuators: pneumatic, hydraulic, electric; Control systems – basic elements, open/closed loop, design of block diagram; control method – P, PI, PID, when to choose what, tuning of controllers;

System models, transfer function and system response, frequency response; Nyquist diagrams and their use.

Practical group based project utilizing above concepts.

Course Outcomes:
Upon completion of this course, the students will be able to understand the measurement of various quantities using instruments, their accuracy & range, and the techniques for controlling devices automatically.

Text Books:
1.Instrumentation and control systems by W. Bolton, 2nd edition, Newnes, 200
2.Thomas G. Beckwith, Roy D. Marangoni, John H. LienhardV , Mechanical Measurements (6th Edition) 6th Edition, Pearson Education India, 2007
3.Gregory K. McMillan, Process/Industrial Instruments and Controls Handbook, Fifth Edition, McGraw-Hill: New York,1999.

PCC-ME 301	**Heat Transfer**	**3L:1T:0P**	**4 credits**

Objectives:
(1) The aim of the course is to build a solid foundation in heat transfer exposing students to the three basic modes namely conduction, convection and radiation.
(2) Rigorous treatment of governing equations and solution procedures for the three modes will be provided, along with solution of practical problems using empirical correlations.
(3) The course will also briefly cover boiling and condensation heat transfer, and the analysis and design of heat exchangers.

Contents :
Introduction to three modes of heat transfer, Derivation of heat balance equation- Steady one dimensional solution for conduction heat transfer in Cartesian, cylindrical and spherical geometry, concept of conduction and film resistances, critical insulation thickness, lumped system approximation and Biot number, heat transfer through pin fins- Two dimensional conduction solutions for both steady and unsteady heat transfer-approximate solution to unsteady conduction heat transfer by the use of Heissler charts.**(12)**

Heat convection,basic equations, boundary layers- Forced convection, external and internal flows- Natural convective heat transfer- Dimensionless parameters for forced and free convection heat transfer-Correlations for forced and free convection- Approximate solutions to laminar boundary layer equations (momentum and energy) for both internal and external flow- Estimating heat transfer rates in laminar and turbulent flow situations using appropriate correlations for free and forced convection. **(8)**

Interaction of radiation with materials, definitions of radiative properties, Stefan Boltzmann's law, black and gray body radiation, Calculation of radiation heat transfer between surfaces using radiative properties, view factors and the radiosity method.**(8)**

Types of heat *exchangers, Analysis and design of heat exchangers using bothLMTD and ε-*NTU methods.**(6)**

Boiling and Condensation heat transfer, Pool boiling curve **(3)**

Introduction mass transfer, Similarity between heat and mass transfer **(3)**

Total number of hours (40 lectures + 12 tutorials)

Course Outcomes:

1. After completing the course, the students will be able to formulate and analyze a heat transfer problem involving any of the three modes of heat transfer
2. The students will be able to obtain exact solutions for the temperature variation using analytical methods where possible or employ approximate methods or empirical correlations to evaluate the rate of heat transfer
3. The students will be able to design devices such as heat exchangers and also estimate the insulation needed to reduce heat losses where necessary.

Text Books:

1. A. Bejan, Heat Transfer John Wiley, 1993
2. J.P.Holman, Heat Transfer, Eighth Edition, McGraw Hill, 1997.
3. F.P.Incropera, and D.P. Dewitt, Fundamentals of Heat and Mass Transfer, John Wiley, Sixth Edition, 2007.
4. MassoudKaviany, Principles of Heat Transfer, John Wiley, 2002
5. Yunus A Cengel, Heat Transfer : A Practical Approach, McGraw Hill, 2002

PCC-ME 302	Solid Mechanics	3L:1T:0P	4 credits

Objectives:

The objective is to present the mathematical and physical principles in understanding the linear continuum behavior of solids.

Course Contents:

Introduction to Cartesian tensors, Strains: Concept of strain, derivation of small strain tensor and compatibility, Stress: Derivation of Cauchy relations and equilibrium and symmetry equations, principal stresses and directions

Constitutive equations: Generalized Hooke's law, Linear elasticity, Material symmetry; Boundary Value Problems: concepts of uniqueness and superposition.

Plane stress and plane strain problems, introduction to governing equations in cylindrical and spherical coordinates, axisymmetric problems.

Application to thick cylinders, rotating discs, torsion of non-circular cross-sections, stress concentration problems, thermo-elasticity, 2-d contact problems.

Solutions using potentials. Energy methods. Introduction to plasticity.

Course Outcomes:
Upon completion of this course, students will be able understand the deformation behavior of solids under different types of loading and obtain mathematical solutions for simple geometries.

Text Books:
[1] G. T. Mase, R. E. Smelser and G. E. Mase, Continuum Mechanics for Engineers, Third Edition, CRC Press, 2004.
[2] Y. C. Fung, Foundations of Solid Mechanics, Prentice Hall International, 1965.
[3] Lawrence. E. Malvern, Introduction to Mechanics of a Continuous Medium, Prentice Hall international, 1969.

PCC-ME 303	Manufacturing Processes	3L:0T:0P	3 credits

Objectives:
To motivate and challenge students to understand and develop an appreciation of the processes in correlation with material properties which change the shape, size and form of the raw materials into the desirable product by conventional or unconventional manufacturing methods

Contents:
Conventional Manufacturing processes:
Casting and moulding: Metal casting processes and equipment, Heat transfer and solidification, shrinkage, riser design, casting defects and residual stresses. **(5)**

Introduction to bulk and sheet metal forming, plastic deformation and yield criteria; fundamentals of hot and cold working processes; load estimation for bulk forming(forging, rolling, extrusion, drawing) and sheet forming (shearing, deep drawing, bending) principles of powder metallurgy.**(4)**

Metal cutting: Single and multi-point cutting; Orthogonal cutting, various force components: Chip formation, Tool wear and tool life, Surface finish and integrity, Machinability, Cutting tool materials, Cutting fluids, Coating; Turning, Drilling, Milling and finishing processes, Introduction to CNC machining.**(8)**

Additive manufacturing: Rapid prototyping and rapid tooling**(3)**

Joining/fastening processes: Physics of welding, brazing and soldering;design considerations in welding,Solid and liquid state joining processes;Adhesive bonding. **(4)**

Unconventional Machining Processes:
Abrasive Jet Machining, Water Jet Machining, Abrasive Water Jet Machining, Ultrasonic Machining, principles and process parameters **(5)**

Electrical Discharge Machining, principle and processes parameters, MRR, surface finish, tool wear, dielectric, power and control circuits, wire EDM; Electro-chemical machining (ECM), etchant &maskant, process parameters, MRR and surface finish. **(8)**

Laser Beam Machining (LBM), Plasma Arc Machining (PAM) and Electron Beam Machining **(3)**

Course Outcomes:
Upon completion of this course, students will be able to understand the different conventional and unconventional manufacturing methods employed for making different products

Text Books:

1. Kalpakjian and Schmid, Manufacturing processes for engineering materials (5th Edition)- Pearson India, 2014
2. Mikell P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems
3. Degarmo, Black &Kohser, Materials and Processes in Manufacturing

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PCC-ME 304	**Kinematics and Theory of Machines**	**3L:1T:0P**	**4 credits**

Objectives:

- To understand the kinematics and rigid- body dynamics of kinematically driven machine components
- To understand the motion of linked mechanisms in terms of the displacement, velocity and acceleration at any point in a rigid link
- To be able to design some linkage mechanisms and cam systems to generate specified output motion
- To understand the kinematics of gear trains

Contents :
Classification of mechanisms- Basic kinematic concepts and definitions- Degree of freedom, mobility- Grashof’s law, Kinematic inversions of four bar chain and slider crank chains- Limit positions- Mechanical advantage- Transmission angle- Description of some common mechanisms- Quick return mechanism, straight line generators- Universal Joint- Rocker mechanisms**(8)**

Displacement, velocity and acceleration analysis of simple mechanisms, graphical velocity analysis using instantaneous centers, velocity and acceleration analysis using loop closure equations- kinematic analysis of simple mechanisms- slider crank mechanism dynamics-

Coincident points- Coriolis component of acceleration- introduction to linkage synthesis- three position graphical synthesis for motion and path generation**(8)**

Classification of cams and followers- Terminology and definitions- Displacement diagrams- Uniform velocity, parabolic, simple harmonic and cycloidal motions- derivatives of follower motions- specified contour cams- circular and tangent cams- pressure angle and undercutting, sizing of cams, graphical and analytical disc cam profile synthesis for roller and flat face followers **(8)**

Involute and cycloidal gear profiles, gear parameters, fundamental law of gearing and conjugate action, spur gear contact ratio and interference/undercutting- helical, bevel, worm, rack & pinion gears, epicyclic and regular gear train kinematics**(8)**

Surface contacts- sliding and rolling friction- friction drives- bearings and lubrication- friction clutches- belt and rope drives- friction in brakes **(8)**
(Total: 40 lectures + 12 tutorials)

Course Outcomes:

- After completing this course, the students can design various types of linkage mechanisms for obtaining specific motion and analyse them for optimal functioning

Text Books:

1. Thomas Bevan, Theory of Machines, 3rd edition, CBS Publishers & Distributors, 2005.
2. CleghornW.L. , Mechanisms of Machines, Oxford University Press, 2005.
3. Robert L. Norton, Kinematics and Dynamics of Machinery, Tata McGrawHill, 2009.
4. Ghosh A. and Mallick A.K., Theory of Mechanisms and Machines, Affiliated East-West Pvt. Ltd, New Delhi, 1988.

PCC-ME 305	Mechanical Engineering Laboratory (Thermal) I	0L:0T:3P	1.5 credits

Objectives:
(i) To understand the principles and performance characteristics of flow and thermal devices
(ii) To know about the measurement of the fluid properties

Contents:
1. Measurement of Coefficient of Discharge of given Orifice and Venturi meters
2. Determination of the density & viscosity of an oil and friction factor of oil flow in a pipe
3. Determination of the performance characteristics of a centrifugal pump
4. Determination of the performance characteristics of Pelton Wheel
5. Determination of the performance characteristics of a Francis Turbine
6. Determination of the performance characteristics of a Kaplan Turbine
7. Determination of the thermal conductivity and specific heat of given objects
8. Determination of the calorific value of a given fuel and its flash & fire points
9. Determination of the p-V diagram and the performance of a 4-stroke diesel engine
10. Determination of the convective heat transfer coefficient for flow over a heated plate

11. Determination of the emissivity of a given sample
12. Determination of the performance characteristics of a vapour compression system

Course Outcomes:
The students who have undergone the course will be able to measure various properties of fluids and characterize the performance of fluid/thermal machinery

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PROJ-ME 306	**Project I**	**(30 hours)**

Objectives:
This course is aimed to provide more weightage for project work. The project work could be done in the form of a summer project or internship in the industry or even a minor practical project in the college. Participation in any technical event/ competition to fabricate and demonstrate an innovative machine or product could be encouraged under this course.

PCC-ME 307	**Manufacturing Technology**	**4L:0T:0P**	**4 credits**

Objectives:
(i)To provide knowledge onmachines and related tools for manufacturing various components.
(ii) To understand the relationship between process and system in manufacturing domain.
(iii) To identify the techniques for the quality assurance of the products and the optimality of the process in terms of resources and time management.

Course Contents:
Tooling for conventional and non-conventional machining processes: Mould and die design, Press tools, Cutting tools; Holding tools: Jigs and fixtures, principles, applications and design; press tools – configuration, design of die and punch; principles of forging die design. **(12)**

Metrology: Dimensions, forms and surface measurements, Limits, fits and tolerances; linear and angular measurements; comparators; gauge design; interferometry; Metrology in tool wear and part quality including surface integrity, alignment and testing methods; tolerance analysis in manufacturing and assembly. Process metrology for emerging machining processes such as micro-scale machining, Inspection and workpiece quality. **(16)**

Assembly practices: Manufacturing and assembly, process planning, selective assembly, Material handling and devices. **(6)**

Linear programming, objective function and constraints, graphical method, Simplex and duplex algorithms, transportation assignment, Traveling Salesman problem; Network models: shortest route, minimal spanning tree, maximum flow model- Project networks: CPM and PERT, critical path scheduling; Production planning& control: Forecasting models, aggregate production planning, materials requirement planning. Inventory Models: Economic Order Quantity, quantity discount models, stochastic inventory models, practical inventory control models, JIT. Simple queuing theory models.**(16)**

Course Outcomes:
Upon completion of this course, students will be able to the tooling needed for manufacturing, the dimensional accuracy and tolerances of products, assembly of different components and the application of optimization methods in manufacturing.

Text Books:

(i) Kalpakjian and Schmid, Manufacturing processes for engineering materials (5th Edition)- Pearson India, 2014.
(ii) Taha H. A., Operations Research, 6th Edition, Prentice Hall of India, 2003.
(iii) Shenoy G.V. and Shrivastava U.K., Operations Research for Management, Wiley Eastern, 1994.

PCC-ME 308	**Design of Machine Elements**	**3L:1T:0P**	**4 credits**

Objectives:
This course seeks to provide an introduction to the design of machine elements commonly encountered in mechanical engineering practice, through 1. A strong background in mechanics of materials based failure criteria underpinning the safety-critical design of machine components 2. An understanding of the origins, nature and applicability of empirical design principles, based on safety considerations 3. An overview of codes, standards and design guidelines for different elements 4. An appreciation of parameter optimization and design iteration 5. An appreciation of the relationships between component level design and overall machine system design and performance

Course Contents:
Design considerations - limits, fits and standardization, Review of failure theories for static and dynamic loading (including fatigue failure), Design of shafts under static and fatigue loadings, Analysis and design of sliding and rolling contact bearings, Design of transmission elements: spur, helical, bevel and worm gears; belt and chain drives, Design of springs: helical compression, tension, torsional and leaf springs, Design of joints: threaded fasteners, pre-loaded bolts and welded joints, Analysis and applications of power screws and couplings, Analysis of clutches and brakes

Course Outcomes:
Upon completion of this course, students will get an overview of the design methodologies employed for the design of various machine components.

Text Books:

[1] Shigley, J.E. and Mischke, C.R., Mechanical Engineering Design, Fifth Edition, McGraw-Hill International; 1989.
[2] Deutschman, D., Michels, W.J. and Wilson, C.E., Machine Design Theory and Practice, Macmillan, 1992.
[3] Juvinal, R.C., Fundamentals of Machine Component Design, John Wiley, 1994.
[4] Spottes, M.F., Design of Machine elements, Prentice-Hall India, 1994.
[5] R. L. Norton, Mechanical Design – An Integrated Approach, Prentice Hall, 1998

PCC-ME 309	Mechanical Engineering Laboratory (Design) II	0L:0T:3P	1.5 credits

Objectives:

(i) To understand the measurement of mechanical properties of materials
(ii) To understand the deformation behaviour of materials
(iii) To understand the kinematic and dynamic characteristics of mechanical devices

Contents

1. Uniaxial tension test on mild steel rod
2. Torsion test on mild steel rod
3. Impact test on a metallic specimen
4. Brinnell and Rockwell hardness tests on metallic specimen
5. Bending deflection test on beams
6. Strain measurement using Rosette strain gauge
7. Microscopic examination of heat-treated and untreated metallic samples
8. Velocity ratios of simple, compound, epicyclic and differential gear trains
9. Kinematics of four bar, slider crank, crank rocker, double crank, double rocker and oscillating cylinder mechanisms
10. Cam & follower and motion studies
11. Single degree of freedom Spring-mass-damper system, determination of natural frequency and damping coefficient
12. Determination of torsional natural frequency of single and double rotor systems-undamped and damped natural frequencies

Course Outcomes:

Students who have undergone the course will be able to understand the measurement of mechanical properties of materials and will be able to characterize the dynamic behavior of mechanical systems

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PROJ -ME 310	**Project II**	**90 hours**

Objectives:
This course is aimed to provide more weightage for project work. The project work could be done in the form of a summer project or internship in the industry or even a minor practical project in the college. Participation in any technical event/ competition to fabricate and demonstrate an innovative machine or product could be encouraged under this course.

PCC-ME401	**Automation in manufacturing**	**3L:0T:0P**	**3 credits**

Objectives:

1. To understand the importance of automation in the of field machine tool based manufacturing
2. To get the knowledge of various elements of manufacturing automation – CAD/CAM, sensors, pneumatics, hydraulics and CNC
3. To understand the basics of product design and the role of manufacturing automation

Course Contents:
Introduction: Why automation, Current trends, CAD, CAM, CIM; Rigid automation: Part handling, Machine tools. Flexible automation: Computer control of Machine Tools and Machining Centers, NC and NC part programming, CNC-Adaptive Control, Automated Material handling. Assembly, Flexible fixturing.

Computer Aided Design: Fundamentals of CAD - Hardware in CAD-Computer Graphics Software and Data Base, Geometric modeling for downstream applications and analysis methods; Computer Aided Manufacturing: CNC technology, PLC, Micro-controllers, CNC-Adaptive Control

Low cost automation: Mechanical & Electro mechanical Systems, Pneumatics and Hydraulics, Illustrative Examples and case studies

Introduction to Modeling and Simulation: Product design, process route modeling, Optimization techniques, Case studies & industrial applications.

Course Outcomes:
Upon completion of this course, the students will get a comprehensive picture of computer based automation of manufacturing operations

Text Books:
(i)Mikell P. Groover, Automation, Production Systems, and Computer-integrated Manufacturing, prentice Hall
(ii) SeropeKalpakjian and Steven R. Schmid, Manufacturing – Engineering and Technology, 7th edition,Pearson

(iii) YoramKoren, Computer control of manufacturing system, 1st edition
(iv) Ibrahim Zeid , CAD/CAM : Theory & Practice, 2nd edition.

ME402	**Mechanical Engineering Laboratory III (Manufacturing)**	**0L:0T:3P**	**1.5 credits**

Objectives:

1. To provide an understanding of advanced manufacturing methods.
2. To get an idea of the dimensional & form accuracy of products

Contents :

About 12 experiments will be carried out as listed below.

1. Taper turning and external thread cutting using lathe
2. Contour milling using vertical milling machine
3. Spur gear cutting in milling machine
4. Measurement of cutting forces in Milling/ Turning process
5. CNC part programming
6. Drilling of a small hole using wire EDM
7. Microprocessor controlled pick & place robot
8. Use of Tool Maker's Microscope
9. Comparator and sine bar
10. Surface finish measurement equipment
11. Bore diameter measurement using micrometer and telescopic gauge
12. Use of Autocollimator

Course Outcomes:

Upon completion of this course, students will be able to perform some advanced manufacturing operations and also be able to evaluate the accuracy & tolerance of components produced

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PROJ-ME 403(Project III) &PROJ-ME 404 (Project IV)

Objectives:

It is intended to start the project work early in the seventh semester and carry out both design and fabrication of a mechanical device whose working can be demonstrated. The design is expected to be completed in the seventh semester and the fabrication and demonstration will be carried out in the eighth semester.

PROFESSIONAL ELECTIVE COURSES

PEC-MEL 321	**Internal Combustion Engines**	**3L:0T:0P**	**3 credits**

Objectives:

1. To familiarize with the terminology associated with IC engines.
2. To understand the basics of IC engines.
3. To understand combustion, and various parameters and variables affecting it in various types of IC engines.
4. To learn about various systems used in IC engines and the type of IC engine required for various applications

Course Contents: Review of ideal cycles; Details of fuel-air cycles. Combustion in SI and CI engines, Combustion stages, Combustion chambers and Abnormal combustion. Fuel supply systems in SI and CI engines, carburettors, Port fuel injection, Direct injection and Common rail injection. Ignition system, Lubrication system and Cooling system. Testing of IC engines. Engine emissions and control. Advanced IC Engine concepts.

Course Outcomes:

Students who have done this course will have a good idea of the basics of IC engines and how different parameters influence the operational characteristics of IC Engines

Text Books:

1. Obert E. F, "Internal Combustion Engines and Air Pollution", Harper and Row Publication Inc. NY, 1973.
2. Heisler H, "Advanced Engine Technology", Edward Arnold, 1995.
3. Heywood J. B, "Internal Combustion Engine Fundamentals", McGraw Hill Book Co. NY, 1989
4. Heldt P. M, "High Speed Combustion Engines", Oxford & IBH publishing Co. India, 1985.
5. Stockel M W, Stockel T S and Johanson C, "Auto Fundamentals", The Goodheart, Wilcox Co. Inc., Illinois, 1996.

PEC-MEL 322	**Mechatronic Systems**	**3L:0T:0P**	**3 credits**

Description:

(i) Tounderstand the structure of microprocessors and their applications in mechanical devices
(ii) To understand the principle of automatic control and real time motion control systems, with the help of electrical drives and actuators
(iii) To understand the use of micro-sensors and their applications in various fields

Course Contents:

Introduction: Definition of Mechanical Systems, Philosophy and approach; Systems and Design: Mechatronic approach, Integrated Product Design, Modeling, Analysis and Simulation, Man-Machine Interface;

Sensors and transducers: classification, Development in Transducer technology, Opto-electronics-Shaft encoders, CD Sensors, Vision System, etc.;

Drives and Actuators: Hydraulic and Pneumatic drives, Electrical Actuators such as servo motor and Stepper motor, Drive circuits, open and closed loop control; Embedded Systems: Hardware Structure, Software Design and Communication, Programmable Logic Devices, Automatic Control and Real Time Control Systems;

Smart materials: Shape Memory Alloy, Piezoelectric and Magnetostrictive Actuators: Materials, Static and dynamic characteristics, illustrative examples for positioning, vibration isolation, etc.;

Micromechatronic systems: Microsensors, Microactuators; Micro-fabrication techniques LIGA Process: Lithography, etching, Micro-joining etc. Application examples; Case studies Examples of Mechatronic Systems from Robotics Manufacturing, Machine Diagnostics, Road vehicles and Medical Technology.

Course Outcomes:
Upon completion of this course, students will get an overview of mechatronics applications and the use of micro-sensors and microprocessors.

Text Books:
1) Mechatronics System Design, Devdas Shetty & Richard A. Kolk, PWS Publishing Company (Thomson Learning Inc.)
2) Mechatronics: A Multidisciplinary Approach, William Bolton, Pearson Education
3) A Textbook of Mechatronics ,R.K.Rajput, S. Chand & Company Private Limited
4) Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, William Bolton, Prentice Hall

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PEC-MEL 323	**Microprocessors in Automation**	**3L:0T:0P**	**3 credits**

Objectives:
To introduce the basic concepts of Digital circuits, Microprocessor system and digital controller

Course Contents: Number Systems, codes, digital electronics: Logic Gates, combinational circuits design, Flip-flops, Sequential logic circuits design: Counters, Shift registers.
Introduction to 8085 Functional Block Diagram, Registers, ALU, Bus systems, Timing and control signals.

Machine cycles, instruction cycle and timing states, instruction timing diagrams, Memory interfacing.

Assembly Language Programming: Addressing modes, Instruction set, simple programs in 8085; Concept of Interrupt, Need for Interrupts, Interrupt structure, Multiple Interrupt requests and their handling, Programmable interrupt controller; Interfacing peripherals: Programmable peripheral interface (8255).

Interfacing Analog to Digital Converter & Digital to Analog converter, Multiplexed seven segments LED display systems, Stepper Motor Control, Data Communication: Serial Data communication (8251), Programmable Timers (8253); 8086/8088 Microprocessor and its advanced features,

Introduction to Digital Control: Sampling theorem, Signal conversion and Processing, Z-Transform, Digital Filters, Implementation of Digital Algorithm.

Course Outcomes:
Students who have done this course will have a good idea of the use of microprocessers for automation.

Text Books:
1) Digital Electronics: An Introduction to Theory and Practice, William H. Gothmann, PHI Learning Private Limited
2) Digital Computer Electronics: An Introduction to Microcomputers, Albert Paul Malvino, Tata McGraw-Hill Publishing Company Ltd.
3) Microprocessor Architecture, Programming, and Applications with the 8085, Ramesh Gaonkar, PENRAM International Publishers.
4) Digital Control Systems, Benjamin C. Kuo, Oxford University Press (2/e, Indian Edition, 2007).
5) Microcomputer Experimentation with the Intel SDK-85, Lance A. Leventhal, Prentice Hall

PEC-MEL 324	Composite Materials	3L:0T:0P	3 credits

Objectives:
1. To understand the mechanical behaviour of composite materials
2. To get an overview of the methods of manufacturing composite materials

Contents:
Definition and applications of composite materials, Fibers- glass, carbon, ceramic and aramid fibers; Matrices- polymer, graphite, ceramic and metal matrices; characteristics of fibers and matrices. Lamina- assumptions, macroscopic viewpoint, generalized Hooke;s law, reduction of homogeneous orthotropic lamina, isotropic limit case, orthotropic stiffness matrix, commercial material properties, rule of mixtures, transformation matrix, transformed stiffness.

Manufacturing of composite materials, bag moulding, compression moulding, pultrusion, filament welding, other manufacturing processes

Basic assumptions of laminated anisotropic plates, symmetric laminates, angle ply laminates, cross ply laminates, laminate structural moduli, evaluation of lamina properties, determination of lamina stresses, maximum stress and strain criteria, von Mises Yield criterion for isotropic materials, generalized Hill's criterion for anisotropic materials, Tsai-Hill's criterion for composites, prediction of laminate failure, thermal analysis of composite laminates

Analysis of laminated plates- equilibrium equations of motion, energy formulation, static bending analysis, buckling analysis, free vibrations, natural frequencies

Course Outcomes:
Upon completion of this course, the students will have an overview of the mechanical behaviour and application of composite materials

Text Books:
1. Gibson R.F. Principles of Composite Material Mechanics, second edition, McGraw Hill, 1994.
2. Hyer M.W., Stress Analysis of Fiber- Reinforced Composite Materials, McGraw Hill, 1998.

PEC-MEL 325	**Computer Aided Design**	**3L:0T:0P**	**3 credits**

Objectives:
To provide an overview of how computers can be utilized in mechanical component design

Contents:
Fundamentals of Computer Graphics- Product cycle, sequential and concurrent engineering, Computer Aided Design, CAD system architecture, computer graphics, Coordinate systems, 2D and 3D transformations, viewing transformation

Geometric Modeling- representation of curves, Hermite curves, Bezier curves, B-spline curves, rational curves, Techniques of surface modelling, surface patch, Coons and bicubic patches, Bezier and B-spline surfaces, Solid modelling techniques, CSG and B-rep.

Visual realism- hidden line-surface-solid removal algorithms, shading, colouring, computer animation

Assembly of parts- assembly modelling, interferences of positions and orientation, tolerance analysis, mass property calculations, mechanism simulation and interefence checking
CAD standards- Graphical Kernel System (GKS), standards for vexchange images, Open Graphics Library (OpenGL), Data exchange standards- IGES, STEP, CALS etc., Communication standards

Course Outcomes:
Upon completion of this course, the students can use computer and CAD software for modelling mechanical components

Text Books:

1. Ibrahim Zeid, Mastering CAD CAM, Tata McGraw Hill Publishing Co. 2007.
2. C. McMohan and J. Browne, CAD/CAM Principles, II edition, Pearson Education, 1999.
3. W. M. Neumann and R.F. Sproul, Principles of Computer Gra[hics, McGraw Hill, 1989.
4. D. Hearn and M.P> Baker, Computer Graphics, Prentice Hall Inc., 1992.

PEC-MEL 421	**Refrigeration and Air Conditioning**	**3L:0T:0P**	**3 credits**

Objectives:

1. To familiarize with the terminology associated with refrigeration systems and air conditioning 2. To understand basic refrigeration processes
3. To understand the basics of psychrometry and practice of applied psychrometrics
4. To acquire the skills required to model, analyse and design different refrigeration as well as air conditioning processes and components

Course Content:

Classification of refrigeration systems

Advanced vapour compression cycles, Refrigerants and their mixtures: properties and characteristics - Ozone depletion and global warming issues - System components: Compressors, Condensers, Expansion devices and Evaporators -Performance matching of components of refrigeration systems

Advanced sorption refrigeration systems and their components.

Review of Psychrometry and Air-conditioning processes - Comfort air conditioning and Cooling load calculations - Applications of AC systems - Concept of enthalpy potential - Air washers, Cooling towers, Evaporative condensers, Cooling and dehumidifying coils.

Course Outcomes:

A student who has done the course will have a good understanding of the working principles of refrigeration and air-conditioning systems.

Text Books:

1. Gosney, W.B, Principles of Refrigeration, Cambridge University Press, 1982.
2. Stoecker, W.F. and Jones, J.W., Refrigeration and Air conditioning, Tata McGraw Hill, 1986.
3. Arora, C.P., Refrigeration and Air conditioning, Tata McGraw Hill, 2nd Edition, 2000.
4. Kuehn, T.H., Ramsey, J.W. and Threlkeld, J.L., Thermal Environmental Engineering, 3rd Edition, Prentice Hall, 1998.

PEC-MEL 422	Finite Element Analysis	3L:0T:0P	3 credits

Objectives:

1. To illustrate the principle of mathematical modeling of engineering problems
2. To introduce the basics and application of Finite Element Method

Contents:

Historical Background, Mathematical modeling of field problems in engineering, governing equations, discrete and continuous models, boundary and initial value problems, Weighted Residual Methods, Variational formulation of boundary value problems, Ritz technique, Basic concept of Finite Element Method.

One dimensional second order equation, discretization, linear and higher order elements, derivation of shape functions, Stiffness matrix and force vectors, assembly of elemental matrices, solution of problems from solid mechanics and heat transfer, longitudinal vibration and mode shapes, fourth order beam equation, transverse deflections and natural frequencies.

Two dimensional equations, variational formulation, finite element formulation, triangular elements- shape functions, elemental matrices and RHS vectors; application to thermal problems, torsion of non-circular shafts, quadrilateral and higher order elements. Plane stresses and plane strain problems, body forces and thermal loads, plate and shell elements.

Natural coordinate systems, isoparametric elements and shape functions, numerical integration and application to plane stress problems, matrix solution techniques, solution of dynamic problems, introduction to FE software.

Course Outcomes:

Upon completion of the course, students will understand the FEM formulation and its application to simple structural and thermal problems

Text Books:

1. Reddy J.N., An Introduction to Finite Element Method, 3rd ed., Tata McGraw Hill, 2005.
2. Seshu P., Text Book of Finite Element Analysis, Prentice Hall, New Delhi, 2007.
3. Rao S.S., The Finite Element Method in Engineering, 3rd ed., Butterworth Heinemann, 2004.
4. Chandraputla&Belegundu, Introduction to Finite Elements in Engineering, 3rd ed., Prentice Hall, 1990.

PEC-MEL 423	Power Plant Engineering	3L:0T:0P	3 credits

Objectives:
To provide an overview of power plants and the associated energy conversion issues

Contents:
Coal based thermal power plants, basic Rankine cycle and its modifications, layout of modern coal power plant, super critical boilers, FBC boilers, turbines, condensers, steam andheating rates, subsystems of thermal power plants, fuel and ash handling, draught system, feed water treatment, binary cycles and cogeneration systems

Gas turbine and combined cycle power plants, Brayton cycle analysis and optimization, components of gas turbine power plants, combined cycle power plants, Integrated Gasifier based Combined Cycle (IGCC) systems.

Basics of nuclear energy conversion, Layout and subsystems of nuclear power plants, Boiling Water Reactor (BWR), Pressurized Water Reactor (PWR), CANDU Reactor, Pressurized Heavy Water Reactor (PHWR), Fast Breeder Reactors (FBR), gas cooled and liquid metal cooled reactors, safety measures for nuclear power plants.

Hydroelectric power plants, classification, typical layout and components, principles of wind, tidal, solar PV and solar thermal, geothermal, biogas and fuel cell power systems

Energy, economic and environmental issues, power tariffs, load distribution parameters, load curve, capital and operating cost of different power plants, pollution control technologies including waste disposal options for coal and nuclear plants.

Course Outcomes:
Upon completion of the course, the students can understand the principles of operation for different power plants and their economics.

Text Books:
1. Nag P.K., Power Plant Engineering, 3rd ed., Tata McGraw Hill, 2008.
2. El Wakil M.M., Power Plant Technology, Tata McGraw Hill, 2010.
3. Elliot T.C., Chen K and Swanekamp R.C., Power Plant Engineering, 2nd ed., McGraw Hill, 1998.

PEC-MEL 424	**Gas Dynamics and Jet Propulsion**	**3L:0T:0P**	**3 credits**

Objectives:

1. To understand the features of compressible isentropic flows and irreversibilities like shocks.
2. To provide a basic knowledge of jet and rocket propulsion technologies.

Contents:

Compressible flow, definition, Mach waves and Mach cone, stagnation states, Mass, momentum and energy equations of one-dimensional flow, Isentropic flow through variable area ducts, nozzle s and diffusers, subsonic and supersonic flow I variable area ducts, choked flow, Area-Mach number relations for isentropic flow

Non-isentropic flow in constant area ducts, Rayleigh and Fanno flows, Normal shock relations, oblique shock relations, isentropic and shock tables

Theory of jet propulsion, thrust equation, thrust power and propulsive efficiency, Operating principle and cycle analysis of ramjet, turbojet, turbofan and turboprop engines.

Types of rocket engines, propellants & feeding systems, ignition and combustion, theory of rocket propulsion, performance study, staging, terminal and characteristic velocity, space flights

Course Outcomes:

Upon completion of this course, the students will be able to apply gas dynamics principles to jet and space propulsion systems

Text Books:

1. Ahmed F. El-Sayed, Aircraft Prpoulsion and Gas Turbine Engines, CRC Press, 2008.
2. H.S. Mukunda, “Understanding Aerospace Chemical Propulsion”, Interline Publishing, 2004.
3. Hill P. and Peterson C., Mechanics & Thermodynamics of Propulsion, Addison Wesley, 1992.
4. Zucrow N. J., Aircraft and Missile Propulsion, Vol.I& II, John Wiley, 1975.
5. Sutton G.P., Rocket Propulsion Elements, John Wiley, New York, 1986.

PEC-MEL 425	**Process Planning and Cost Estimation**	**3L:0T:0P**	**3 credits**

Objectives:
To introduce process planning concepts to make cost estimation for various products

Contents:
Introduction of Process Planning- methods of process planning, drawing interpretation, material evaluation, steps in process selection, production equipment and tooling selection

Process planning activities- process parameter calculation for various production processes, selection of jigs and fixtures, selection of quality assurance methods, documents for process planning, economics of process planning, case studies

Introduction to cost estimation- importance of costing and estimation, methods of costing, elements of cost estimation, types of estimates, estimating procedure, estimation of labor cost, material cost, allocation of overhead charges, calculation of depreciation cost

Machining time estimation- importance of machine time calculation, machining time for different lathe operations, drilling and boring time calculations, Machining time calculation for Milling, Shaping, Planing and Grinding

Production costs- different production processes for different jobs, estimation of forging cost, estimation of welding cost, estimation of foundry cost, estimation of machining cost

Course Outcomes:
Upon completion of this course, the students will be able to use the concepts of process planning and cost estimation for various products

Text Books:

1. Peter Scalon, Process Planning, Design/ Manufacture Interface, Elsevier Sci.&Tech. 2002.
2. Ostwaal P.F. and Munez J., Manufacturing Processes and Systems, 9th ed., John Wiley 1998.
3. Chitale A.V. and Gupta R.C., Product Design and Manufacturing, 2nd ed., Prentice Hall 2002.

PEC-MEL 431	Principles of Management	3L:0T:0P	3 credits

Objectives:

To understand the principles of management and their application to the functioning of an organization

Contents:

Definition of management, science or art, manager vs entrepreneur; Types of managers-managerial roles and skills; Evolution of management- scientific, human relations, system and contingency approaches; Types of Business Organizations, sole proprietorship, partnership, company, public and private enterprises; Organization culture and environment; Current trends and issues in management.

Nature and purpose of Planning, types of Planning, objectives, setting objectives, policies, Strategic Management, Planning Tools and Techniques, Decision making steps & processes.

Nature and purpose of Organizing, formal and informal organization, organization structure, types, line and staff authority, departmentalization, delegation of authority, centralization and decentralization, job design, human resource management, HR planning, Recruitment selection, Training & Development, Performance Management, Career planning and Management.

Directing, individual and group behavior, motivation, motivation theories, motivational techniques, job satisfaction, job enrichment, leadership, types & theories of leadership, effective communication.

Controlling, system and process of controlling, budgetary and non-budgetary control techniques, use of computers and IT in management control, productivity problems and management, control and performance, direct and preventive control, reporting.

Course Outcomes:

Upon completion of this course, the students will get a clear understanding of management functions in an organization

Text Books:

1. Robins S.P. and Couiter M., Management, Prentice Hall India, 10th ed., 2009.
2. Stoner JAF, Freeman RE and Gilbert DR, Management, 6th ed., Pearson Education, 2004.
3. Tripathy PC & Reddy PN, Principles of Management, Tata McGraw Hill, 1999.

PEC-MEL 432	Automobile Engineering	3L:0T:0P	3 credits

Objectives:
To understand the construction and working principle of various parts of an automobile

Contents:
Types of automobiles, vehicle construction and layouts, chassis, frame and body, vehicle aerodynamics, IC engines- components, function and materials, variable valve timing (VVT). Engine auxiliary systems, electronic injection for SI and CI engines, unit injector system, rotary distributor type and common rail direct injection system, transistor based coil ignition & capacitive discharge ignition systems, turbo chargers (WGT, VGT), engine emission control by 3-way catalytic converter system, Emission norms (Euro & BS).

Transmission systems, clutch types & construction, gear boxes- manual and automatic gear shift mechanisms, Over drive, transfer box, flywheel, torque converter, propeller shaft, slip joints, universal joints, differential and rear axle, Hotchkiss drive and Torque tube drive.

Steering geometry and types of steering gear box, power steering, types of front axle, types of suspension systems, pneumatic and hydraulic braking systems, antilock braking system (ABS), electronic brake force distribution (EBD) and traction control.

Alternative energy sources, natural gas, LPG, biodiesel, bio-ethanol, gasohol and hydrogen fuels in automobiles, modifications needed, performance, combustion & emission characteristics of alternative fuels in SI and CI engines, Electric and Hybrid vehicles, application of Fuel Cells

Course Outcomes:
Upon completion of this course, students will understand the function of each automobile component and also have a clear idea about the overall vehicle performance.

Text books:

1. Kirpal Singh, Automobile Engineering, 7th ed., Standard Publishers, New Delhi, 1997.
2. Jain K.K. and Asthana R.B., Automobile Engineering, Tata McGraw Hill, New Delhi, 2002.
3. Heitner J., Automotive Mechanics, 2nd ed., East-West Press, 1999.
4. Heisler H., Advanced Engine Technology, SAE International Publ., USA, 1998.

PEC-MEL 433	Design of Transmission Systems	3L:0T:0P	3 credits

Objectives:
To learn about the design procedures for mechanical power transmission components

Contents:
Flexible transmission elements- design of flat belts & pulleys, selection of V-belts and pulleys, selection of hoisting wire ropes and pulleys, design of chains and sprockets

Gear transmission- speed ratios and number of teeth, force analysis, tooth stresses, dynamic effects, fatigue strength, factor safety, gear materials; Design of straight tooth spur gear and parallel axis helical gears based on strength and wear considerations, pressure angle in the normal and transverse plane; equivalent number of teeth and forces for helical gears.

Straight bevel gear- tooth terminology, tooth forces and stresses, equivalent number of teeth. Estimating the dimensions of a pair of straight bevel gears; Worm gear, merits & demerits, terminology, thermal capacity, materials, forces & stresses, efficiency, estimating the size of worm gear pair. Cross helical gears, terminology, helix angles, sizing of a pair of helical gears.

Gear box- geometric progression, standard step ratio; Ray diagram, kinematics layout; Design of sliding mesh gear box- Design of multi-seed gear box for machine tool applications; constant mesh gear box, speed reducer unit; Variable speed gear box; Fluid couplings, Torque converters for automotive applications.

Cam design, types: pressure angle and undercutting base circle determination, forces and surface stresses; Design of plate clutches, axial clutches, cone clutches, internal expanding rim clutches; Electromagnetic clutches; Band and Block brakes, external shoe brakes, internal expanding shoe brake.

Course Outcomes:
Upon completing this course the students will be able to design transmission systems for engines and machines.

Text Books:
1. Shigley J., Mischke C., Budynas R. and Nisbett K., Mechanical Engineering Design, 8th ed., Tata McGraw Hill, 2010.
2. Jindal U.C., Machine Design: Design of Transmission System, Dorling Kindersley, 2010.
3. Maitra G. and Prasad L., Handbook of Mechanical Design, 2nd ed., Tata McGraw Hill, 2001.

PEC-MEL 434	Total Quality Management	3L:0T:0P	3 credits

Objectives:
To facilitate the understanding of total quality management principles and processes

Contents:
Introduction, need for quality, evolution of quality; Definitions of quality, product quality and service quality; Basic concepts of TQM, TQM framework, contributions of Deming, Juran and Crosby. Barriers to TQM; Quality statements, customer focus, customer orientation & satisfaction, customer complaints, customer retention; costs to quality.

TQM principles; leadership, strategic quality planning; Quality councils- employee involvement, motivation; Empowerment; Team and Teamwork; Quality circles, recognition and reward, performance appraisal; Continuous process improvement; PDCE cycle, 5S, Kaizen; Supplier partnership, Partnering, Supplier rating & selection.

The seven traditional tools of quality; New management tools; Six sigma- concepts, methodology, applications to manufacturing, service sector including IT, Bench marking process; FMEA- stages, types.

TQM tools and techniques, control charts, process capability, concepts of six sigma, Quality Function Development (QFD), Taguchi quality loss function; TPM- concepts, improvement needs, performance measures.

Quality systems, need for ISO 9000, ISO 9001-9008; Quality system- elements, documentation,; Quality auditing, QS 9000, ISO 14000- concepts, requirements and benefits; TQM implementation in manufacturing and service sectors.

Course Outcomes:
Upon completion of this course, the students will be able to use the tools and techniques of TQM in manufacturing and service sectors.

Text Books:

1. Besterfield D.H. et al., Total qualityManagement, 3rd ed., Pearson Education Asia, 2006.
2. Evans J.R. and Lindsay W.M., The management and Control of Quality, 8th ed., first Indian edition, Cengage Learning, 2012.
3. Janakiraman B. and Gopal R.K., Total Quality Management, Prentice Hall India, 2006.
4. Suganthi L. and Samuel A., Total Quality Management, Prentice Hall India, 2006.

PEC-MEL 435	**Energy Conservation and Management**	**3L:0T:0P**	**3 credits**

Objectives:
To understand the energy data from industries and carry out energy audit for energy savings

Contents:
Introduction to energy & power scenario of world, National Energy consumption data, environmental aspects associated with energy utilization; Energy Auditing- need, types, methodology and barriers, role of energy managers, instruments of energy auditing.

Components of EB billing, HT and LT supply, transformers, cable sizing; Concept of capacitors, power factor improvement, harmonics; Electric motors- motor efficiency computation, energy efficient motors; Illumination- Lux, Lumens, types of lighting, efficacy, LED lighting and scope of energy conservation in lighting.

Thermal systems, Boilers, Furnaces and Thermic Fluid heaters- efficiency computation and energy conservation measures; Steam distribution and usage, steam traps, condensate recovery, flash steam utilization; Insulation & Refractories.

Energy conservation in major utilities; pumps, fans, blowers, compressed air systems, Refrigeration& Air Conditioning systems, Cooling Towers, DG sets.
Energy Economics- discount period, payback period, internal rate of return, net present value; Life Cycle costing- ESCO concept.

Course Outcomes:
Upon completion of this course, the students will be able to perform of energy auditing for the energy consumption of industries.

Text Books:
1. Witte L.C. , Schmidt P.S. and Brown D.R., Industrial Energy Management and Utilization, Hemisphere Publ., Washington, 1988..
2. Callaghn P.W., Design and Management for Energy Conservation, Pergamon Press, Oxford, 1981.
3. Murphy W.R. and McKay G., Energy Management, Butterworths, London, 1987.
4. Energy Manager Training Manual , Bureau of Energy Efficiency (BEE) under Ministry of Power, GOI, 2004 (available at www.energymanager training.com).

MODEL CURRICULUM

for

UNDERGRADUATE DEGREE COURSES
IN

COMPUTER SCIENCE & ENGINEERING

(Engineering & Technology)

[January 2018]

ALL INDIA COUNCIL FOR TECHNICAL EDUCATION
Nelson Mandela Marg, Vasant Kunj, New Delhi 110 070
www.aicte-india.org

All India Council for Technical Education
Model curriculum for
Undergraduate Degree Courses in Engineering & Technology

COMPUTER SCIENCE AND ENGINEERING

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All India Council for Technical Education
Model curriculum for
Undergraduate Degree Courses in Engineering & Technology

COMPUTER SCIENCE AND ENGINEERING

Chapter -1

General, Course structure & Theme
&
Semester-wise credit distribution

A. Definition of Credit:

1 Hr. Lecture (L) per week	1 credit
1 Hr. Tutorial (T) per week	1 credit
1 Hr. Practical (P) per week 2 Hours Practical(Lab)/week	0.5 credit 1 credit

B. Range of credits -A range of credits from 150 to 160 for a student to be eligible to get Under Graduate degree in Engineering. A student will be eligible to get Under Graduate degree with Honours or additional Minor Engineering, if he/she completes an additional 20 credits. These could be acquired through MOOCs.

C. Structure of Undergraduate Engineering program :

S. No.		Credit Breakup for CSE students
1	Humanities and Social Sciences including Management courses	12
2	Basic Science courses	24
3	Engineering Science courses including workshop, drawing, basics of electrical/mechanical/computer etc	29
4	Professional core courses	49
5	Professional Elective courses relevant to chosen specialization/branch	18
6	Open subjects – Electives from other technical and /or emerging subjects	12
7	Project work, seminar and internship in industry or elsewhere	15
8	Mandatory Courses [Environmental Sciences, Induction Program, Indian Constitution, Essence of Indian Traditional Knowledge]	(non-credit)
	Total	159*

**Minor variation is allowed as per need of the respective disciplines.*

D. Credit distribution in the First year of Undergraduate Engineering program :

	Lecture	Tutorial	Laboratory/Practica	Total credits
Chemistry-I	3	1	3	5.5
Physics	3	1	3	5.5
Maths-1	3	1	0	4
Maths -2	3	1	0	4
Programming for Problem solving	3	0	4	5
English	2	0	2	3
Engineering Graphics & Design	1	0	4	3
Workshop/ Practical	1	0	4	3
Basic Electrical Engg.	3	1	2	5
*Biology	2	1	0	3
*Maths-3	3	1	0	4

These courses may be offered preferably in the later semesters

E. Course code and definition:

Course code	Definitions
BSC	Basic Science Courses
ESC	Engineering Science Courses
HSMC	Humanities and Social Sciences including Management courses
PCC-CS	Professional core courses
PEC -CS	Professional Elective courses
OEC-CS	Open Elective courses
LC	Laboratory course
MC	Mandatory courses
SI	Summer Industry Internship
PROJ-CS	Project

HUMANITIES AND SOCIAL SCIENCES INCLUDING MANAGEMENT COURSES

Sl. No	Code No.	Course Title	Hours per week			Total Credits	Semester
			Lecture	Tutorial	Practical		
1	HSMC 201	English	2	0	2	3	2
2	HSMC 301	Humanities – 1	3	0	0	3	3
3	HSMC 401	Management-I (Organizational Behaviour)/ Finance & Accounting	3	0	0	3	4
4	HSMC 501	Humanities – II	3	0	0	3	5
					Total Credits:	**12**	

BASIC SCIENCE COURSE [BSC]

Sl. No	Code No.	Course Title	Hours per week			Total Credits	Semester
			Lecture	Tutorial	Practical		
1	BSC101	Physics (Semi-conductor Physics)	3	1	3	5.5	1
2	BSC 201	Mathematics-II (Probability and Statistics)	3	1	0	4	2
3	BSC 102	Mathematics-I (Calculus and Linear Algebra)	3	1	0	4	1
4	BSC 202	Chemistry-I	3	1	3	5.5	2
5	BSC 701	Biology	2	1	0	3	7
6	BSC 301	Mathematics-III (Differential Calculus)	2	0	0	2	3
					Total Credits:	**24**	

ENGINEERING SCIENCE COURSE [ESC]

Sl. No	Code No.	Course Title	Hours per week			Total Credits	Semester
			Lecture	Tutorial	Practical		
1	ESC 101	Basic Electrical Engineering	3	1	2	5	1
2	ESC 102	Engineering Graphics & Design	1	0	4	3	1
3	ESC 201	Programming for Problem Solving	3	0	4	5	2
4	ESC 202	Workshop/Manufacturing Practices	1	0	4	3	2
5	ESC 301	Analog Electronic Circuits	3	0	4	5	3
6	ESC 302	Digital Electronics	3	0	4	5	4
7	ESC 501	Signals and Systems	3	0	0	3	5
					Total Credits:	**29**	

PROFESSIONAL CORE COURSES [PCC]

Sl. No	Code No.	Course Title	Hours per week			Total Credits	Semester
			Lecture	Tutorial	Practical		
1	PCC CS301	Data Structure & Algorithms	3	0	4	5	3
2	PCC CS302	IT Workshop – (Sci Lab/MATLAB)	1	0	4	3	3
3	PCC CS401	Discrete Mathematics	3	1	0	4	4
4	PCC CS402	Computer Organization and Architecture	3	0	4	5	3
5	PCC CS403	Operating Systems	3	0	4	5	4
6	PCC CS404	Design and Analysis of Algorithms	3	0	4	5	4
7	PCC CS 501	Database Management Systems	3	0	4	5	5

8	PCC CS502	Formal Language, Automats and Complier	3	0	0	3	5
9	PCC CS503	Object Oriented Programming	2	0	4	4	5
10	PCC CS601	Complier Design	3	0	4	5	6
11	PCC CS602	Computer Networks	3	0	4	5	6
					Total Credits	**49**	

PROFESSIONAL ELECTIVE [PEC]

Sl. No	**Code No.**	**Course Title**	**Hours per week**			**Total Credits**	**Semester**
			Lecture	Tutorial	Practical		
1	PEC	Elective – I	3	0	0	3	5
2	PEC	Elective-II	3	0	0	3	6
3	PEC	Elective-III	3	0	0	3	6
4	PEC	Elective-IV	3	0	0	3	7
5	PEC	Elective-V	3	0	0	3	7
6	PEC	Elective-VI	3	0	0	3	8
					Total Credits	**18**	

OPEN ELECTIVE COURSES [OEC]

Sl. No	**Code No.**	**Course Title**	**Hours per week**			**Total Credits**	**Semester**
			Lecture	Tutorial	Practical		
1	OEC	Open Elective – I	3	0	0	3	6
2	OEC	Open-Elective-II	3	0	0	3	7
3	OEC	Open-Elective-III	3	0	0	3	8
4	OEC	Open-Elective-IV	3	0	0	3	8
					Total Credits:	**12**	

4 year Curriculum structure
Undergraduate Degree in Engineering & Technology

Branch / course :Computer Science and Engineering
Total credits (4 year course): 159

I. I. Induction Program (Please refer Appendix-A for guidelines)

Induction program (mandatory)	**3 weeks duration** (Please refer Appendix-A for guidelines & also details available in the curriculum of Mandatory courses)
Induction program for students to be offered right at the start of the first year.	• Physical activity • Creative Arts • Universal Human Values • Literary • Proficiency Modules • Lectures by Eminent People • Visits to local Areas • Familiarization to Dept./Branch & Innovations

II Semester-wise structure of curriculum

[L= Lecture, T = Tutorials, P = Practicals & C = Credits]

Semester I (First year] Curriculum
Branch/Course: Computer Science Engineering

Sl. No.	Type of course	Course Code	Course Title	Hours per week			Credits
				Lecture	Tutorial	Practical	
1	Basic Science course	BSC 101	Physics (semi-conductor Physics)	3	1	3	5.5
2	Basic Science course	BSC 102	Mathematics-1 (Calculus & Linear Algebra)	3	1	0	4
3	Engineering Science Course	ESC 101	Basic Electrical Engineering	3	1	2	5
4	Engineering Science Course	ESC 102	Engineering Graphics & Design	1	0	4	3
			Total credits				**17.5**

Semester II (First year] Curriculum
Branch/Course: Computer Science Engineering

Sl. No.	Type of course	Code	Course Title	Hours per week			Credits
				Lecture	Tutorial	Practical	
1	Basic Science course	BSC 202	Chemistry-I	3	1	3	5.5
2	Basic Science course	BSC 201	Mathematics-II (Probability and Statistics)	3	1	0	4
3	Engineering Science Course	ESC 201	Programming for Problem Solving	3	0	4	5
4	Engineering Science Course	ESC 202	Workshop /Manufacturing Practices	1	0	4	3
5	Humanities & Social Sciences including Management	HSMC 201	English	2	0	2	3
						Total credits	**20.5**

Semester III (Second year] Curriculum
Branch/Course: Computer Science Engineering

Sl. No.	Type of course	Code	Course Title	Hours per week			Credits
				Lecture	Tutorial	Practical	
1	Engineering Science Course	ESC 301	Analog Electronic Circuits	3	0	4	5
2	Professional Core Courses	PCC-CS301	Data structure & Algorithms	3	0	4	5
3	Professional Core Courses	ESC 302	Digital Electronics	3	0	4	5
4	Professional Core Courses	PCC-CS302	IT Workshop (Sci Lab/MATLAB)	1	0	4	3
5	Basic Science course	BSC 301	Mathematics-III (Differential Calculus)	2	0	0	2
6	Humanities & Social Sciences including Management courses	HSMC 301	Humanities-I	3	0	0	3
						Total credits	**23**

Semester IV (Second year] Curriculum
Branch/Course: Computer Science Engineering

Sl. No.	Type of course	Code	Course Title	Hours per week			Credits
				Lecture	Tutorial	Practical	
1	Professional Core Courses	PCC-CS401	Discrete Mathematics	3	1	0	4
2	Engineering Science Course	PCC-CS 402	Computer Organization & Architecture	3	0	4	5
3	Professional Core Courses	PCC-CS403	Operating Systems	3	0	4	5
4	Professional Core Courses	PCC-CS404	Design & Analysis of Algorithms	3	0	4	5
5	Humanities &Social Sciences including Management courses	HSMC 401	Management 1 (Organizational Behaviour/ Finance & Accounting)	3	0	0	3
6	Mandatory Courses	MC	Environmental Sciences	-	-	-	0
						Total credits	**22**

Semester V (Third year] Curriculum
Branch/Course: Computer Science Engineering

Sl. No.	Type of course	Code	Course Title	Hours per week			Credits
				Lecture	Tutorial	Practical	
1	Engineering Science Course	ESC501	Signals & Systems	3	0	0	3
2	Professional Core Courses	PCC-CS501	Database Management Systems	3	0	4	5
3	Professional Core Courses	PCC-CS502	Formal Language & Automata Theory	3	0	0	3
4	Professional Core Courses	PCC-CS503	Object Oriented Programming	2	0	4	4
5	Humanities &Social Sciences including Management courses	HSMC-501	Humanities II	3	0	0	3
6	Professional Elective courses	PEC	Elective-I	3	0	0	3
7	Mandatory Courses	MC	Constitution of India/ Essence of Indian Traditional Knowledge	-	-	-	0
						Total credits	**21**

Semester VI (Third year] Curriculum
Branch/Course: Computer Science Engineering

Sl. No.	Type of course	Code	Course Title	Hours per week			Credits
				Lecture	Tutorial	Practical	
1	Professional Core Courses	PCC-CS601	Complier Design	3	0	4	5
2	Professional Core Courses	PCC-CS602	Computer Networks	3	0	4	5
3	Professional Elective courses	PEC	Elective-II	3	0	0	3
4	Professional Elective courses	PEC	Elective-III	3	0	0	3
5	Open Elective courses	OEC	Open Elective-I (Humanities)	3	0	0	3
6	Project	PROJ -CS60	Project-1	0	0	6	3
						Total credits	**22**

Semester VII (Fourth year] Curriculum
Branch/Course: Computer Science Engineering

Sl. No.	Type of course	Code	Course Title	Hours per week			Credits
				Lecture	Tutorial	Practical	
1	Professional Elective courses	PEC	Elective-IV	3	0	0	3
2	Professional Elective courses	PEC	Elective-V	3	0	0	3
3	Open Elective courses	OEC	Open Elective-II	3	0	0	3
4	Basic Science course	BSC 701	Biology	2	1	0	3
5	Project	PROJ-CS70	Project-II	0	0	12	6
						Total credits	**18**

Semester VIII (Fourth year) Curriculum
Branch/Course: Computer Science Engineering

[Summer Industry Internship]

Sl. No.	Type of course	Code	Course Title	Hours per week			Credits
				Lecture	Tutorial	Practical	
1	Professional Elective courses	PEC	Elective-VI	3	0	0	3
2	Open Elective courses	OEC	Open Elective-III	3	0	0	3
3	Open Elective courses	OEC	Open Elective-IV	3	0	0	3
4	Project	PROJ-	Project-III	0	0	12	6
						Total credits	**15**

CHAPTER 2

DETAILED 4-YEAR CURRICULUM CONTENTS

Undergraduate Degree in Engineering & Technology

Branch/Course: COMPUTER SCIENCE AND ENGINEERING

Second year (Third semester onwards)

PROFESSIONAL CORE COURSES

PCC-CS301	Data Structure & Algorithms	3L:0T: 4P	5 credits

Pre-requisites	ESC 201

Objectives of the course:

1. To impart the basic concepts of data structures and algorithms.
2. To understand concepts about searching and sorting techniques
3. To understand basic concepts about stacks, queues, lists, trees and graphs.
4. To enable them to write algorithms for solving problems with the help of fundamental data structures

Detailed contents:

Module 1:

Introduction: Basic Terminologies: Elementary Data Organizations, Data Structure Operations: insertion, deletion, traversal etc.; Analysis of an Algorithm, Asymptotic Notations, Time-Space trade off. **Searching:** Linear Search and Binary Search Techniques and their complexity analysis.

Module 2:

Stacks and Queues: ADT Stack and its operations: Algorithms and their complexity analysis, Applications of Stacks: Expression Conversion and evaluation – corresponding algorithms and complexity analysis. ADT queue, Types of Queue: Simple Queue, Circular Queue, Priority Queue; Operations on each types of Queues: Algorithms and their analysis.

Module 3:

Linked Lists: Singly linked lists: Representation in memory, Algorithms of several operations: Traversing, Searching, Insertion into, Deletion from linked list; Linked representation of Stack and Queue, Header nodes, Doubly linked list: operations on it and algorithmic analysis; Circular Linked Lists: all operations their algorithms and the complexity analysis.

Trees: Basic Tree Terminologies, Different types of Trees: Binary Tree, Threaded Binary Tree, Binary Search Tree, AVL Tree; Tree operations on each of the trees and their algorithms with complexity analysis. Applications of Binary Trees. B Tree, B+ Tree: definitions, algorithms and analysis.

Module 4:

Sorting and Hashing: Objective and properties of different sorting algorithms: Selection Sort, Bubble Sort, Insertion Sort, Quick Sort, Merge Sort, Heap Sort; Performance and Comparison among all the methods, Hashing.

Graph: Basic Terminologies and Representations, Graph search and traversal algorithms and complexity analysis.

Suggested books:

1. “Fundamentals of Data Structures”, Illustrated Edition by Ellis Horowitz, Sartaj Sahni, Computer Science Press.

Suggested reference books:

1. Algorithms, Data Structures, and Problem Solving with C++", Illustrated Edition by Mark Allen Weiss, Addison-Wesley Publishing Company

2. "How to Solve it by Computer", 2nd Impression by R. G. Dromey, Pearson Education.

Course outcomes

1. For a given algorithm student will able to analyze the algorithms to determine the time and computation complexity and justify the correctness.
2. For a given Search problem (Linear Search and Binary Search) student will able to implement it.
3. For a given problem of Stacks, Queues and linked list student will able to implement it and analyze the same to determine the time and computation complexity.
4. Student will able to write an algorithm Selection Sort, Bubble Sort, Insertion Sort, Quick Sort, Merge Sort, Heap Sort and compare their performance in term of Space and Time complexity.
5. Student will able to implement Graph search and traversal algorithms and determine the time and computation complexity.

PCC-CS401	**Discrete Mathematics**	**3L:1T:0P**	**4 Credits**

Objectives of the course

Throughout the course, students will be expected to demonstrate their understanding of Discrete Mathematics by being able to do each of the following:

1. Use mathematically correct terminology and notation.
2. Construct correct direct and indirect proofs.
3. Use division into cases in a proof.
4. Use counterexamples.
5. Apply logical reasoning to solve a variety of problems.

Detailed contents:

Module 1:

Sets, Relation and Function: Operations and Laws of Sets, Cartesian Products, Binary Relation, Partial Ordering Relation, Equivalence Relation, Image of a Set, Sum and Product of Functions, Bijective functions, Inverse and Composite Function, Size of a Set, Finite and infinite Sets, Countable and uncountable Sets, Cantor's diagonal argument and The Power Set theorem, Schroeder-Bernstein theorem.

Principles of Mathematical Induction: The Well-Ordering Principle, Recursive definition, The Division algorithm: Prime Numbers, The Greatest Common Divisor: Euclidean Algorithm, The Fundamental Theorem of Arithmetic.

Module 2:
Basic counting techniques-inclusion and exclusion, pigeon-hole principle, permutation and combination.

Module 3:
Propositional Logic: Syntax, Semantics, Validity and Satisfiability, Basic Connectives and Truth Tables, Logical Equivalence: The Laws of Logic, Logical Implication, Rules of Inference, The use of Quantifiers. **Proof Techniques:** Some Terminology, Proof Methods and Strategies, Forward Proof, Proof by Contradiction, Proof by Contraposition, Proof of Necessity and Sufficiency.

Module 4:
Algebraic Structures and Morphism: Algebraic Structures with one Binary Operation, Semi Groups, Monoids, Groups, Congruence Relation and Quotient Structures, Free and Cyclic Monoids and Groups, Permutation Groups, Substructures, Normal Subgroups, Algebraic Structures with two Binary Operation, Rings, Integral Domain and Fields. Boolean Algebra and Boolean Ring, Identities of Boolean Algebra, Duality, Representation of Boolean Function, Disjunctive and Conjunctive Normal Form

Module 5:
Graphs and Trees: Graphs and their properties, Degree, Connectivity, Path, Cycle, Sub Graph, Isomorphism, Eulerian and Hamiltonian Walks, Graph Colouring, Colouring maps and Planar Graphs, Colouring Vertices, Colouring Edges, List Colouring, Perfect Graph, definition properties and Example, rooted trees, trees and sorting, weighted trees and prefix codes, Bi-connected component and Articulation Points, Shortest distances.

Suggested books :
1. Kenneth H. Rosen, Discrete Mathematics and its Applications, Tata McGraw – Hill
2. Susanna S. Epp, Discrete Mathematics with Applications,4th edition, Wadsworth Publishing Co. Inc.
3. C L Liu and D P Mohapatra, Elements of Discrete Mathematics A Computer Oriented Approach, 3rd Edition by, Tata McGraw – Hill.

Suggested reference books:
1. J.P. Tremblay and R. Manohar, Discrete Mathematical Structure and It's Application to Computer Science", TMG Edition, TataMcgraw-Hill
2. Norman L. Biggs, Discrete Mathematics, 2nd Edition, Oxford University Press. Schaum's Outlines Series, Seymour Lipschutz, Marc Lipson,
3. Discrete Mathematics, Tata McGraw - Hill

Course Outcomes
1. For a given logic sentence express it in terms of predicates, quantifiers, and logical connectives
2. For a given a problem, derive the solution using deductive logic and prove the solution based on logical inference
3. For a given a mathematical problem, classify its algebraic structure
4. Evaluate Boolean functions and simplify expressions using the properties of Boolean algebra
5. Develop the given problem as graph networks and solve with techniques of graph theory.

PCC-CS402	Computer Organization &Architecture	3L:0T:4P	5 Credits

Pre-requisites	ESC 302

Objectives of the course:

To expose the students to the following :

1. How Computer Systems work & the basic principles
2. Instruction Level Architecture and Instruction Execution
3. The current state of art in memory system design
4. How I/O devices are accessed and its principles.
5. To provide the knowledge on Instruction Level Parallelism
6. To impart the knowledge on micro programming
7. Concepts of advanced pipelining techniques.

Detailed contents:

Module 1

Functional blocks of a computer: CPU, memory, input-output subsystems, control unit. Instruction set architecture of a CPU – registers, instruction execution cycle, RTL interpretation of instructions, addressing modes, instruction set. Case study – instruction sets of some common CPUs.

Data representation: signed number representation, fixed and floating point representations, character representation. Computer arithmetic – integer addition and subtraction, ripple carry adder, carry look-ahead adder, etc. multiplication – shift-andadd, Booth multiplier, carry save multiplier, etc. Division restoring and non-restoring techniques, floating point arithmetic.

Module 2:

Introduction to x86 architecture.

CPU control unit design: hardwired and micro-programmed design approaches, Case study – design of a simple hypothetical CPU.

Memory system design: semiconductor memory technologies, memory organization.

Peripheral devices and their characteristics: Input-output subsystems, I/O device interface, I/O transfers – program controlled, interrupt driven and DMA, privileged and non-privileged instructions, software interrupts and exceptions. Programs and processes – role of interrupts in process state transitions, I/O device interfaces – SCII, USB

Module 3:

Pipelining: Basic concepts of pipelining, throughput and speedup, pipeline hazards.

Parallel Processors: Introduction to parallel processors, Concurrent access to memory and cache coherency.

Module 4:

Memory organization: Memory interleaving, concept of hierarchical memory organization, cache memory, cache size vs. block size, mapping functions, replacement algorithms, write policies.

Suggested books:

1. "Computer Organization and Design: The Hardware/Software Interface", 5th Edition by David A. Patterson and John L. Hennessy, Elsevier.
2. "Computer Organization and Embedded Systems", 6th Edition by CarlHamacher, McGraw Hill Higher Education.

Suggested reference books:

1. "Computer Architecture and Organization", 3rd Edition by John P. Hayes, WCB/McGraw-Hill
2. "Computer Organization and Architecture: Designing for Performance", 10th Edition by William Stallings, Pearson Education.
3. "Computer System Design and Architecture", 2nd Edition by Vincent P. Heuring and Harry F. Jordan, Pearson Education.

Course outcomes

1. Draw the functional block diagram of a single bus **architecture of a computer and describe the function of the** instruction execution cycle, RTL interpretation of instructions, addressing modes, instruction set.
2. **Write** assembly language program for specified microprocessor for computing 16 bit multiplication, division and I/O device interface (ADC, Control circuit, serial port communication).
3. Write a flowchart for Concurrent access to memory and cache coherency in **Parallel Processors** and describe the process.
4. Given a CPU organization and instruction, design a memory module and analyze its operation by interfacing with the CPU.
5. Given a CPU organization, assess its performance, and apply design techniques to enhance performance using pipelining, parallelism and RISC methodology

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PCC- CS403	**Operating Systems**	**3L:0T:4P**	**5 Credits**

Pre-requisites	**PCC – CS402**

Objectives of the course

To learn the fundamentals of Operating Systems.

1. To learn the mechanisms of OS to handle processes and threads and their communication
2. To learn the mechanisms involved in memory management in contemporary OS
3. To gain knowledge on distributed operating system concepts that includes architecture, Mutual exclusion algorithms, deadlock detection algorithms and agreement protocols
4. To know the components and management aspects of concurrency management

Detailed contents

Module 1:

Introduction: Concept of Operating Systems, Generations of Operating systems, Types of Operating Systems, OS Services, System Calls, Structure of an OS - Layered, Monolithic, Microkernel Operating Systems, Concept of Virtual Machine. Case study on UNIX and WINDOWS Operating System.

Module 2:

Processes: Definition, Process Relationship, Different states of a Process, Process State transitions, Process Control Block (PCB), Context switching

Thread: Definition, Various states, Benefits of threads, Types of threads, Concept of multithreads,

Process Scheduling: Foundation and Scheduling objectives, Types of Schedulers, Scheduling criteria: CPU utilization, Throughput, Turnaround Time, Waiting Time, Response Time; Scheduling algorithms: Pre-emptive and Non pre-emptive, FCFS, SJF, RR; Multiprocessor scheduling: Real Time scheduling: RM and EDF.

Module 3:

Inter-process Communication: Critical Section, Race Conditions, Mutual Exclusion, Hardware Solution, Strict Alternation, Peterson's Solution, The Producer\ Consumer Problem, Semaphores, Event Counters, Monitors, Message Passing, Classical IPC Problems: Reader's & Writer Problem, Dinning Philosopher Problem etc.

Module 4:

Deadlocks: Definition, Necessary and sufficient conditions for Deadlock, Deadlock Prevention, Deadlock Avoidance: Banker's algorithm, Deadlock detection and Recovery.

Module 5:

Memory Management: Basic concept, Logical and Physical address map, Memory allocation: Contiguous Memory allocation – Fixed and variable partition– Internal and External fragmentation and Compaction; Paging: Principle of operation – Page allocation – Hardware support for paging, Protection and sharing, Disadvantages of paging.

Virtual Memory: Basics of Virtual Memory – Hardware and control structures – Locality of reference, Page fault , Working Set , Dirty page/Dirty bit – Demand paging, Page Replacement algorithms: Optimal, First in First Out (FIFO), Second Chance (SC), Not recently used (NRU) and Least Recently used (LRU).

Module 6:

I/O Hardware: I/O devices, Device controllers, Direct memory access Principles of I/O Software: Goals of Interrupt handlers, Device drivers, Device independent I/O software, Secondary-Storage Structure: Disk structure, Disk scheduling algorithms

File Management: Concept of File, Access methods, File types, File operation, Directory structure, File System structure, Allocation methods (contiguous, linked, indexed), Free-space management (bit vector, linked list, grouping), directory implementation (linear list, hash table), efficiency and performance.

Disk Management: Disk structure, Disk scheduling - FCFS, SSTF, SCAN, C-SCAN, Disk reliability, Disk formatting, Boot-block, Bad blocks

Suggested books:

1. Operating System Concepts Essentials, 9th Edition by AviSilberschatz, Peter Galvin, Greg Gagne, Wiley Asia Student Edition.
2. Operating Systems: Internals and Design Principles, 5th Edition, William Stallings, Prentice Hall of India.

Suggested reference books:

1. Operating System: A Design-oriented Approach, 1st Edition by Charles Crowley, Irwin Publishing
2. Operating Systems: A Modern Perspective, 2nd Edition by Gary J. Nutt, Addison-Wesley
3. Design of the Unix Operating Systems, 8th Edition by Maurice Bach, Prentice-Hall of India
4. Understanding the Linux Kernel, 3rd Edition, Daniel P. Bovet, Marco Cesati, O'Reilly and Associates

Course Outcomes

1. Create processes and threads.
2. Develop algorithms for process scheduling for a given specification of CPU utilization, Throughput, Turnaround Time, Waiting Time, Response Time.
3. For a given specification of memory organization develop the techniques for optimally allocating memory to processes by increasing memory utilization and for improving the access time.
4. Design and implement file management system.
5. For a given I/O devices and OS (specify) develop the I/O management functions in OS as part of a uniform device abstraction by performing operations for synchronization between CPU and I/O controllers.

PCC-CS-404	**Design and Analysis of Algorithms**	**3L:0T: 4P**	**5 Credits**

Pre-requisites	**ESC 201**

Objectives of the course

- Analyze the asymptotic performance of algorithms.
- Write rigorous correctness proofs for algorithms.
- Demonstrate a familiarity with major algorithms and data structures.
- Apply important algorithmic design paradigms and methods of analysis.
- Synthesize efficient algorithms in common engineering design situations.

Detailed contents:

Module 1:

Introduction: Characteristics of algorithm. Analysis of algorithm: Asymptotic analysis of complexity bounds – best, average and worst-case behavior; Performance measurements of Algorithm, Time and space trade-offs, Analysis of recursive algorithms through recurrence relations: Substitution method, Recursion tree method and Masters' theorem.

Module 2:

Fundamental Algorithmic Strategies: Brute-Force, Greedy,Dynamic Programming, Branch-and-Bound and Backtracking methodologies for the design of algorithms; Illustrations of these techniques for Problem-Solving , Bin Packing, Knap Sack TSP. Heuristics – characteristics and their application domains.

Module 3:

Graph and Tree Algorithms: Traversal algorithms: Depth First Search (DFS) and Breadth First Search (BFS); Shortest path algorithms, Transitive closure, Minimum Spanning Tree, Topological sorting, Network Flow Algorithm.

Module 4:

Tractable and Intractable Problems: Computability of Algorithms, Computability classes – P, NP, NP-complete and NP-hard. Cook's theorem, Standard NP-complete problems and Reduction techniques.

Module 5:

Advanced Topics: Approximation algorithms, Randomized algorithms, Class of problems beyond NP – P SPACE

Suggested books:

1. Introduction to Algorithms, 4TH Edition, Thomas H Cormen, Charles E Lieserson, Ronald L Rivest and Clifford Stein, MIT Press/McGraw-Hill.
2. Fundamentals of Algorithms – E. Horowitz et al.

Suggested reference books

1. Algorithm Design, 1ST Edition, Jon Kleinberg and ÉvaTardos, Pearson.
2. Algorithm Design: Foundations, Analysis, and Internet Examples, Second Edition, Michael T Goodrich and Roberto Tamassia, Wiley.
3. Algorithms -- A Creative Approach, 3RD Edition, UdiManber, Addison-Wesley, Reading, MA.

Course Outcomes

1. For a given algorithms analyze worst-case running times of algorithms based on asymptotic analysis and justify the correctness of algorithms .
2. Describe the greedy paradigm and explain when an algorithmic design situation calls for it. For a given problem develop the greedy algorithms.
3. Describe the divide-and-conquer paradigm and explain when an algorithmic design situation calls for it. Synthesize divide-and-conquer algorithms. Derive and solve recurrence relation.
4. Describe the dynamic-programming paradigm and explain when an algorithmic design situation calls for it. For a given problems of dynamic-programming and

5. develop the dynamic programming algorithms, and analyze it to determine its computational complexity.
6. For a given model engineering problem model it using graph and write the corresponding algorithm to solve the problems.
7. Explain the ways to analyze randomized algorithms (expected running time, probability of error).
8. Explain what an approximation algorithm is. Compute the approximation factor of an approximation algorithm (PTAS and FPTAS).

PCC-CS501	**Database Management Systems**	**3L:0T:4 P**	**5 Credits**

Pre-requisites	**PCC-CS 403**

Objectives of the course

- To understand the different issues involved in the design and implementation of a database system.
- To study the physical and logical database designs, database modeling, relational, hierarchical, and network models
- To understand and use data manipulation language to query, update, and manage a database
- To develop an understanding of essential DBMS concepts such as: database security, integrity, concurrency, distributed database, and intelligent database, Client/Server (Database Server), Data Warehousing.
- To design and build a simple database system and demonstrate competence with the fundamental tasks involved with modeling, designing, and implementing a DBMS.

Detailed contents

Module 1

Database system architecture: Data Abstraction, Data Independence, Data Definition Language (DDL), Data Manipulation Language (DML).

Data models: Entity-relationship model, network model, relational and object oriented data models, integrity constraints, data manipulation operations.

Module 2:

Relational query languages: Relational algebra, Tuple and domain relational calculus, SQL3, DDL and DML constructs, Open source and Commercial DBMS - MYSQL, ORACLE, DB2, SQL server.

Relational database design: Domain and data dependency, Armstrong's axioms, Normal forms, Dependency preservation, Lossless design.

Query processing and optimization: Evaluation of relational algebra expressions, Query equivalence, Join strategies, Query optimization algorithms.

Module 3:

Storage strategies: Indices, B-trees, hashing.

Module 4:
Transaction processing: Concurrency control, ACID property, Serializability of scheduling, Locking and timestamp based schedulers, Multi-version and optimistic Concurrency Control schemes, Database recovery.

Module 5:
Database Security: Authentication, Authorization and access control, DAC, MAC and RBAC models, Intrusion detection, SQL injection.

Module 6:
Advanced topics: Object oriented and object relational databases, Logical databases, Web databases, Distributed databases, Data warehousing and data mining.

Suggested books:

1. "Database System Concepts", 6th Edition by Abraham Silberschatz, Henry F. Korth, S. Sudarshan, McGraw-Hill.

Suggested reference books

1 "Principles of Database and Knowledge – Base Systems", Vol 1 by J. D. Ullman, Computer Science Press.
2 "Fundamentals of Database Systems", 5th Edition by R. Elmasri and S. Navathe, Pearson Education
3 "Foundations of Databases", Reprint by Serge Abiteboul, Richard Hull, Victor Vianu, Addison-Wesley

Course Outcomes

1. For a given query write relational algebra expressions for that query and optimize the developed expressions
2. For a given specification of the requirement design the databases using E□R method and normalization.
3. For a given specification construct the SQL queries for Open source and Commercial DBMS -MYSQL, ORACLE, and DB2.
4. For a given query optimize its execution using Query optimization algorithms
5. For a given transaction-processing system, determine the transaction atomicity, consistency, isolation, and durability.
6. Implement the isolation property, including locking, time stamping based on concurrency control and Serializability of scheduling.

PCC-CS502	**Formal Language & Automata Theory**	**3L:0T:0 P**	**3 Credits**

Pre-requisites	**PCC-CS 403**

Objectives of the course

- Develop a formal notation for strings, languages and machines.

- Design finite automata to accept a set of strings of a language.
- Prove that a given language is regular and apply the closure properties of languages.
- Design context free grammars to generate strings from a context free language and convert them into normal forms.
- Prove equivalence of languages accepted by Push Down Automata and languages generated by context free grammars
- Identify the hierarchy of formal languages, grammars and machines.
- Distinguish between computability and non-computability and Decidability and undecidability.

Detailed contents

Module 1:

Introduction: Alphabet, languages and grammars, productions and derivation, Chomsky hierarchy of languages. Regular languages and finite automata: Regular expressions and languages, deterministic finite automata (DFA) and equivalence with regular expressions, nondeterministic finite automata (NFA) and equivalence with DFA, regular grammars and equivalence with finite automata, properties of regular languages, pumping lemma for regular languages, minimization of finite automata. Context-free languages and pushdown automata: Context-free grammars (CFG) and languages (CFL), Chomsky and Greibach normal forms, nondeterministic pushdown automata (PDA) and equivalence with CFG, parse trees, ambiguity in CFG, pumping lemma for context-free languages, deterministic pushdown automata, closure properties of CFLs. Context-sensitive languages: Context-sensitive grammars (CSG) and languages, linear bounded automata and equivalence with CSG. Turing machines: The basic model for Turing machines (TM), Turing-recognizable (recursively enumerable) and Turing-decidable (recursive) languages and their closure properties, variants of Turing machines, nondeterministic TMs and equivalence with deterministic TMs, unrestricted grammars and equivalence with Turing machines, TMs as enumerators. Undecidability: Church-Turing thesis, universal Turing machine, the universal and diagonalization languages, reduction between languages and Rice s theorem, undecidable problems about languages.

Suggested books

1. John E. Hopcroft, Rajeev Motwani and Jeffrey D. Ullman, Introduction to Automata Theory, Languages, and Computation, Pearson Education Asia.

Suggested reference books:

1. Harry R. Lewis and Christos H. Papadimitriou, Elements of the Theory of Computation, Pearson Education Asia.
2. Dexter C. Kozen, Automata and Computability, Undergraduate Texts in Computer Science, Springer.
3. Michael Sipser, Introduction to the Theory of Computation, PWS Publishing.
4. John Martin, Introduction to Languages and The Theory of Computation, Tata McGraw Hill.

Course Outcomes:

1. Write a formal notation for strings, languages and machines.
2. Design finite automata to accept a set of strings of a language.
3. For a given language determine whether the given language is regular or not.
4. Design context free grammars to generate strings of context free language .

5. Determine equivalence of languages accepted by Push Down Automata and languages generated by context free grammars
6. Write the hierarchy of formal languages, grammars and machines.
7. Distinguish between computability and non-computability and Decidability and undecidability.

PCC-CS503	**Object Oriented Programming**	**2L:0T:4 P**	**4 Credits**

Pre-requisites	**PCC-CS 301**

Objectives of the course

The course will introduce standard tools and techniques for software development, using object oriented approach, use of a version control system, an automated build process, an appropriate framework for automated unit and integration tests.

Detailed contents

- *Abstract data types and their specification.*
- *How to implement an ADT.* Concrete state space, concrete invariant, abstraction function. Implementing operations, illustrated by the Text example.
- *Features of object-oriented programming.* Encapsulation, object identity, polymorphism – but not inheritance.
- *Inheritance in OO design.*
- *Design patterns.* Introduction and classification. The iterator pattern.
- *Model-view-controller pattern.*
- *Commands as methods* and as objects. • *Implementing OO language features.*
- *Memory management.*
- *Generic types and collections*
- *GUIs.* Graphical programming with Scala and Swing • *The software development process.*

The concepts should be practised using C++ and Java. Pearl may also be introduced wherever possible.

Suggested books

1. Barbara Liskov, *Program Development in Java*, Addison-Wesley, 2001

Suggested reference books

1. Any book on Core Java
2. Any book on C++

Course Outcomes

After taking the course, students will be able to:

1. Specify simple abstract data types and design implementations, using abstraction functions to document them.
2. Recognise features of object-oriented design such as encapsulation, polymorphism, inheritance, and composition of systems based on object identity.
3. Name and apply some common object-oriented design patterns and give examples of their use.
4. Design applications with an event-driven graphical user interface.

PCC-CS601	**Complier Design**	**3L:0T: 4P**	**5 Credits**

Pre-requisites	**PCC-CS 302, PCC-CS 502**

Objectives of the course

- To understand and list the different stages in the process of compilation.
- Identify different methods of lexical analysis
- Design top-down and bottom-up parsers
- Identify synthesized and inherited attributes
- Develop syntax directed translation schemes
- Develop algorithms to generate code for a target machine

Detailed contents

Module 1:

The aim is to learn how to design and implement a compiler and also to study the underlying theories. The main emphasis is for the imperative language. Introduction: Phases of compilation and overview. Lexical Analysis (scanner): Regular languages, finite automata, regular expressions, from regular expressions to finite automata, scanner generator (lex, flex).Syntax Analysis (Parser): Context-free languages and grammars, push-down automata, LL(1) gram-mars and top-down parsing, operator grammars, LR(O), SLR(1), LR(1), LALR(1) grammars and bottom-up parsing, ambiguity and LR parsing, LALR(1) parser generator (yacc, bison)Semantic Analysis: Attribute grammars, syntax directed definition, evaluation and flow of attribute in a syntax tree. Symbol Table: Its structure, symbolattributes and management. Run-time environment: Procedure activation, parameter passing, value return, memory allocation, and scope. Intermediate Code Generation: Translation of different language features, different types of intermediate forms. Code Improvement (optimization): Analysis: control-flow, data-flow dependence etc.; Code improvement local optimization, global optimization, loop optimization, peep-hole optimization etc. Architecture dependent code improvement: instruction scheduling (for pipeline), loop optimization (for cache memory) etc. Register allocation and target code generation Advanced topics: Type systems, data abstraction, compilation of Object Oriented features and non-imperative programming languages.

Course Outcomes

1. For a given grammar specification develop the lexical analyser
2. For a given parser specification design top-down and bottom-up parsers
3. Develop syntax directed translation schemes
4. Develop algorithms to generate code for a target machine

PCC-CS602	**Computer Networks**	**3L:0T: 4P**	**5 Credits**

Pre-requisites	PCC-CS - 402 PCC-CS - 403

Objectives of the course

- To develop an understanding of modern network architectures from a design and performance perspective.
- To introduce the student to the major concepts involved in wide-area networks (WANs), local area networks (LANs) and Wireless LANs (WLANs).
- To provide an opportunity to do network programming
- To provide a WLAN measurement ideas.

Detailed contents

Module 1:

Data communication Components: Representation of data and its flow Networks , Various Connection Topology, Protocols and Standards, OSI model, Transmission Media, LAN: Wired LAN, Wireless LANs, Connecting LAN and Virtual LAN, Techniques for Bandwidth utilization: Multiplexing - Frequency division, Time division and Wave division, Concepts on spread spectrum.

Module 2:

Data Link Layer and Medium Access Sub Layer: Error Detection and Error Correction - Fundamentals, Block coding, Hamming Distance, CRC; Flow Control and Error control protocols - Stop and Wait, Go back – N ARQ, Selective Repeat ARQ, Sliding Window, Piggybacking, Random Access, Multiple access protocols -Pure ALOHA, Slotted ALOHA, CSMA/CD,CDMA/CA

Module 3:

Network Layer: Switching, Logical addressing – IPV4, IPV6; Address mapping – ARP, RARP, BOOTP and DHCP–Delivery, Forwarding and Unicast Routing protocols.

Module 4:

Transport Layer: Process to Process Communication, User Datagram Protocol (UDP), Transmission Control Protocol (TCP), SCTP Congestion Control; Quality of Service, QoS improving techniques: Leaky Bucket and Token Bucket algorithm.

Module 5:

Application Layer: Domain Name Space (DNS), DDNS, TELNET, EMAIL, File Transfer Protocol (FTP), WWW, HTTP, SNMP, Bluetooth, Firewalls, Basic concepts of Cryptography

Suggested books

1. Data Communication and Networking, 4th Edition, Behrouz A. Forouzan, McGraw-Hill.
2. Data and Computer Communication, 8th Edition, William Stallings, Pearson Prentice Hall India.

Suggested reference books

1. Computer Networks, 8th Edition, Andrew S. Tanenbaum, Pearson New International Edition.
2. Internetworking with TCP/IP, Volume 1, 6th Edition Douglas Comer, Prentice Hall of India.
3. TCP/IP Illustrated, Volume 1, W. Richard Stevens, Addison-Wesley, United States of America.

Course Outcomes

1. Explain the functions of the different layer of the OSI Protocol.
2. Draw the functional block diagram of wide-area networks (WANs), local area networks (LANs) and Wireless LANs (WLANs) describe the function of each block.
3. For a given requirement (small scale) of wide-area networks (WANs), local area networks (LANs) and Wireless LANs (WLANs) design it based on the market available component
4. For a given problem related TCP/IP protocol developed the network programming.
5. Configure DNS DDNS, TELNET, EMAIL, File Transfer Protocol (FTP), WWW, HTTP, SNMP, Bluetooth, Firewalls using open source available software and tools.

PROFESSIONAL ELECTIVE COURSES

Additional Courses for B.Tech (Hons.)

Branch/Course: Computer Science Engineering

In order to have an Honours degree, a student choose 19-20 credits from the following courses in addition. The professional electives may be selected **excluding** these.

Sl. No.	Type	Code	Course Title	Hours per week			Credits
				Lecture	Tutorial	Practical	
1	PEC	PEC-CS-T<number>	Graph Theory	3	0	0	3
2	PEC	PEC-CS-S<number>	Software Engineering	3	0	4	5
3	PEC	PEC-CS-S<number>	Embedded Systems	3	0	4	5
4.	PEC	PEC-CS-D<number>	Artificial Intelligence	3	0	0	3
5.	PEC	PEC-CS-A<number>	Cryptography & Network Security	3	0	0	3
6.	PEC	PEC-CS-S<number>	Internet-of-Things	3	0	0	3
7.	PEC	PEC-CS-D<number>	Data Analytics	3	0	0	3
8.	PEC	PEC-CS-D<number>	Machine Learning	3	0	0	3

Electives

Electives will be introduced in 4 threads besides the Open Elective. There are 6 slots for Electives and 4 slots for Open Electives. The department may permit students to take 50% of these (electives + open electives) from other disciplines, based on the choices of the students and consent of course advisors.

A. **Theory** B. **Systems** C. **Data Science** D.**Applications** and E.**Open Electives**

The students will have options of selecting the electives from the different threads depending on the specialization they wish to acquire. **There should be at least two electives from the open elective choices; the rest two can be taken from the other threads, if intended.**

Pls. see the Table.

The Electives are shown in different threads.

The list is suggestive.
The actual list of electives will depend on the availability of faculty and their research interests. **However, there should be courses available in each thread.**

On-line MOOC courses may contribute upto 20% of the credits, with in-house examination being conducted.

Theory and Algorithms **Code: PEC-CS-T<number>**	**Systems** **Code: PEC-CS-S<number>**	**Data Science and Machine Intelligence** **Code: PEC-CS-D <number>**	**Applications** **Code: PEC-CS-A<number>**	**Open Electives** **OEC-CS<number>**
Theory of Computation	Advanced Computer Architecture	Artificial Intelligence	Image Processing	Soft Skills and Interpersonal Communication
Graph Theory	Software Engineering			
Advanced Algorithms	Distributed Systems	Machine Learning	Digital Signal Processing	Human Resource Development and Organizational Behavior
Parallel and Distributed Algorithms	Embedded Systems	Data Mining	Cloud Computing	Cyber Law and Ethics
Computational Complexity	Advanced Operating Systems	Soft Computing	Human Computer Interaction	Introduction
Computational Geometry	Low Power Circuits and Systems	Speech and Natural Language Processing	Electronic Design Automation	Comparative Study
Queuing Theory and Modeling	Fault Tolerant Computing	Data Analytics	Computer Graphics	Indian Music System

Computational Number Theory	Real Time Systems	Information Retrieval	VLSI System Design	History of Science
Quantum Computing	Ad-Hoc and Sensor Networks	Neural Networks and Deep Learning	Optimization Techniques	Introduction to Art and Aesthetics
Information Theory and	Signals and Networks	Multi-agent Intelligent	Web and Internet	Economic Policies in India

Coding		Systems	Technology
	Internet-of-Things	Data Analytics	Cryptography and Network Security

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MODEL CURRICULUM

for

UNDERGRADUATE DEGREE COURSES
IN

ELECTRONICS & COMMUNICATION ENGINEERING

(Engineering & Technology)

[January 2018]

ALL INDIA COUNCIL FOR TECHNICAL EDUCATION
Nelson Mandela Marg, Vasant Kunj, New Delhi 110 070
www.aicte-india.org

All India Council for Technical Education
Model curriculum for
Undergraduate Degree Courses in Engineering & Technology

ELECTRONICS & COMMUNICATION ENGINEERING

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		EC05: Signals and System
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		EC07: Analog and Digital Communication
		EC08: Analog and Digital Communication Laboratory
		EC09: Analog circuits
		EC10: Analog Circuit Laboratory[0L:0T:2P 1 credit]
		EC11: Microcontrollers
		EC12: Microcontroller Lab
		EC13: Electromagnetic Waves
		EC14: Electromagnetic Waves Lab
		EC15: Computer Architecture
		EC16: Probability and Stochastic Processes
		EC17: Digital Signal Processing
		EC18: Digital Signal Processing Laboratory
		EC19: Control Systems
		EC20: Computer Network
		EC21: Computer Network Laboratory
		EC22: Electronics Measurement Lab
		EC23: Mini Project/Electronic Design workshop
	(ii)	**Program Elective Courses**
		ECEL01: Microwave Theory and Techniques
		ECEL02: Fiber Optic Communication
		ECEL03: Information Theory and Coding
		ECEL04: Speech and Audio Processing
		ECEL05: Introduction to MEMS
		ECEL06: Adaptive Signal Processing
		ECEL07: Antennas and Propagation

Sl. No.	Chapter	Title
		ECEL08: Bio-Medical Electronics
		ECEL09: Mobile Communication and Networks
		ECEL10: Digital Image & Video Processing
		ECEL11: Mixed Signal Design
		ECEL12: Wireless Sensor Networks
		ECEL13: CMOS Design
		ECEL14: Power Electronics
		ECEL15: Satellite Communication
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All India Council for Technical Education
Model curriculum for
Undergraduate Degree Courses in Engineering & Technology

ELECTRONICS & COMMUNICATION ENGINEERING

Chapter -1
General, Course structure & Theme
&
Semester-wise credit distribution

A. **Definition of Credit**:

1 Hr. Lecture (L) per week	1 credit
1 Hr. Tutorial (T) per week	1 credit
1 Hr. Practical (P) per week 2 Hours Practical(Lab)/week	1.5 credits 1 credit

B. **Range of credits -** A range of credits from 150 to 160 for a student to be eligible to get Under Graduate degree in Engineering. A student will be eligible to get Under Graduate degree with Honours or additional Minor Engineering, if he/she completes an additional 20 credits. These could be acquired through MOOCs.

C. **Structure of Undergraduate Engineering program :**

S. No.	Category	Suggested Breakup of Credits(Total 161)
1	Humanities and Social Sciences including Management courses	12*
2	Basic Science courses	25*
3	Engineering Science courses including workshop, drawing, basics of electrical/mechanical/computer etc	24*
4	Professional core courses	48*
5	Professional Elective courses relevant to chosen specialization/branch	18*
6	Open subjects – Electives from other technical and /or emerging subjects	18*
7	Project work, seminar and internship in industry or elsewhere	15*
8	Mandatory Courses [Environmental Sciences, Induction Program, Indian Constitution, Essence of Indian Traditional Knowledge]	(non-credit)
	Total	160*

**Minor variation is allowed as per need of the respective disciplines.*

D. Credit distribution in the First year of Undergraduate Engineering program :

	Lecture	Tutorial	Laboratory/Practical	Total credits
Chemistry –I	3	1	3	5.5
Physics	3	1	3	5.5
Maths-1	3	1	0	4
Maths -2	3	1	0	4
Programming for Problem solving	3	0	4	5
English	2	0	2	3
Engineering Graphics & Design	1	0	4	3
Workshop/ Practicals	1	0	4	3
Basic Electrical Engg.	3	1	2	5
*Biology	2	1	0	3
*Engg. Mechanics	3	1	0	4
*Maths-3	3	1	0	4

**These courses may be offered preferably in the 3*rd *semester & onwards.*

E. Course code and definition:

Course code	Definitions
EC	Core Courses
ECEL	Program Electives
ECP1	Project Stage-I
ECP2	Project Stage-II
BS	Basic Science
ES	General Engineering Courses
HS	HUSS
OE	Open Electives
MC	Mandatory Courses

Program Core Courses:

Sr. No.	**Course Code**	**Course Title**	**Hrs. /Week L: T: P**	**Credits**	**Preferred Semester**
1	EC01	Electronic Devices	3:0:0	3	III
2	EC02	Electronics Devices Lab	0:0:2	1	III
3	EC03	Digital System Design	3:0:0	3	III
4	EC04	Digital System Design Lab	0:0:2	1	III
5	EC05	Signals and Systems	3:0:0	3	III
6	EC06	Network Theory	3:0:0	3	III
7	EC07	Analog and Digital Communication	3:0:0	3	IV
8	EC08	Analog and Digital Communication Lab	0:0:2	1	IV
9	EC09	Analog Circuits	3:0:0	3	IV
10	EC10	Analog Circuits Lab	0:0:2	1	IV
11	EC11	Microcontrollers	3:0:0	3	IV
12	EC12	Microcontrollers Lab	0:0:2	1	IV
13	EC13	Electromagnetic Waves	3:0:0	3	V
14	EC14	Electromagnetic Waves Lab	0:0:2	1	V
15	EC15	Computer Architecture	3:0:0	3	V
16	EC16	Probability Theory and Stochastic Processes	3:0:0	3	V
17	EC17	Digital Signal Processing	3:0:0	3	V
18	EC18	Digital Signal Processing Lab	0:0:2	1	V
19	EC19	Control Systems	3:0:0	3	VI
20	EC20	Computer Networks	3:0:0	3	VI
21	EC21	Computer Network Lab	0:0:4	2	VI
22	EC22	Electronics Measurement Lab	0:0:2	1	VI
23	EC23	Mini Project/Electronic Design workshop	0:0:4	2	VI

Program Elective Courses:

Sr. No.	**Course Code**	**Course Title**	**Hrs. /Week L: T: P**	**Credits**	**Preferred Semester**
1	ECEL1	Microwave Theory and Techniques	3:0:0	3	VII/VIII
2	ECEL2	Fiber Optic Communications	3:0:0	3	VII/VIII
3	ECEL3	Information Theory and Coding	3:0:0	3	V/VI
4	ECEL4	Speech and Audio Processing	3:0:0	3	V/VI
5	ECEL5	Introduction to MEMS	3:0:0	3	V/VI
6	ECEL6	Adaptive Signal Processing	3:0:0	3	VII/VIII
7	ECEL7	Antennas and Propagation	3:0:0	3	VII/VIII
8	ECEL8	Bio-Medical Electronics	3:0:0	3	V/VI
9	ECEL9	Mobile Communication and Networks	3:0:0	3	VII/VIII
10	ECEL10	Digital Image & Video Processing	3:0:0	3	VII/VIII
11	ECEL11	Mixed Signal Design	3:0:0	3	VII/VIII
12	ECEL12	Wireless Sensor Networks	3:0:0	3	VII/VIII
13	ECEL13	CMOS Design	3:0:0	3	V/VI
14	ECEL14	Power Electronics	3:0:0	3	V/VI
15	ECEL15	Satellite Communication	3:0:0	3	VII/VIII
16	ECEL16	High Speed Electronics	3:0:0	3	VII/VIII
17	ECEL17	Wavelets	3:0:0	3	VII/VIII
18	ECEL18	Embedded systems	3:0:0	3	VII/VIII
19	ECEL19	Nano electronics	3:0:0	3	V/VI
20	ECEL20	Error correcting codes	3:0:0	3	VII/VIII
21	ECEL21	Scientific computing	3:0:0	3	V/VI

Project/Dissertation:

Sr. No.	**Course Code**	**Course Title**	**Hrs. /Week L: T: P**	**Credits**	**Preferred Semester**
1	ECP1	Project Work I	0: 0: 10	5	VII
2	ECP2	Project Work II & Dissertation	0: 0:18	9	VIII

4 year Curriculum structure
Undergraduate Degree in Engineering & Technology

Branch / course: Electronics & Communication Engineering

I. **Induction Program**(Please refer **Appendix-A** for guidelines. Details of Induction program also available in the curriculum of Mandatory courses.)

Induction program (mandatory)	**3 weeks duration** (Please refer Appendix-A for guidelines & also details available in the curriculum of Mandatory courses)
Induction program for students to be offered right at the start of the first year.	• Physical activity • Creative Arts • Universal Human Values • Literary • Proficiency Modules • Lectures by Eminent People • Visits to local Areas • Familiarization to Dept./Branch & Innovations

II. Semester-wise structure of curriculum

[L= Lecture, T = Tutorials, P = Practicals & C = Credits]

Semester I (First year]
Branch/Course Electronics & Communication Engineering

Sr. No.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Contact Hrs./wk.**	**Credits**
		Slot for BS/ES/HS Courses					17.5
		TOTAL CREDITS					**17.5**
		Slot for MC					

Semester II (First year]
Branch/Course Electronics & Communication Engineering

Sr. No.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Contact Hrs./wk.**	**Credits**
		Slot for BS/ES/HS Courses					20.5
		TOTAL CREDITS					**20.5**
		Slot for MC[Environmental Sc.]					

Semester III (Second year]
Branch/Course Electronics & Communication Engineering

Sr. No.	**Course Code**	**Course Title**	**L**	**T**	**P**	**ContactHrs./wk.**	**Credits**
1	EC01	Electronic Devices	3	0	0	3	3
2	EC02	Electronics Devices Lab	0	0	2	2	1
3	EC03	Digital System Design	3	0	0	3	3
4	EC04	Digital System Design Lab	0	0	2	2	1
5	EC05	Signals and Systems	3	0	0	3	3
6	EC06	Network Theory	3	0	0	3	3
		Slot for BS/ES/HS courses					6
		TOTAL CREDITS					**20**
		Slot for MC [Constitution of India/Essence of Indian Traditional Knowledge]					

Semester IV(Second year]
Branch/Course Electronics & Communication Engineering

Sr. No.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Contacthrs. /wk.**	**Credits**
1	EC07	Analog and Digital Communication	3	0	0	3	3
2	EC08	Analog and Digital Communication Lab	0	0	2	2	1
3	EC09	Analog Circuits	3	0	0	3	3
4	EC10	Analog Circuits Lab	0	0	2	2	1
5	EC11	Microcontrollers	3	0	0	3	3
6	EC12	Microcontrollers Lab	0	0	2	1	1
		Slot for BS/ES/HS courses					8
		TOTAL CREDITS					**20**

Semester V(Third year]
Branch/Course Electronics & Communication Engineering

Sr. No.	Course Code	Course Title	L	T	P	ContactHrs./wk.	Credits
1	EC13	Electromagnetic Waves	3	0	0	3	3
2	EC14	Electromagnetic Waves Lab	0	0	2	2	1
3	EC15	Computer Architecture	3	0	0	3	3
4	EC16	Probability Theory and Stochastic Processes	3	0	0	3	3
5	EC17	Digital Signal Processing	3	0	0	3	3
6	EC18	Digital Signal Processing Lab	0	0	2	2	1
7	ECEL*	Program Elective – 1	3	0	0	3	3
8		OE-1	3	0	0	3	3
		TOTAL CREDITS					**20**

Semester VI(Third year]
Branch/Course Electronics & Communication Engineering

Sr. No.	Course Code	Course Title	L	T	P	Contacthrs. /wk.	Credits
1	EC19	Control Systems	3	0	0	3	3
2	EC20	Computer Network	3	0	0	3	3
3	EC21	Computer Networks Lab	0	0	4	4	2
4	EC22	Electronic Measurement Lab	0	0	2	2	1
5	EC23	Mini Project/Electronic Design workshop	0	0	4	4	2
6	ECEL*	Program Elective – 2	3	0	0	3	3
		OE-2	3	0	0	3	3
		Slot for HS/BS					3
		TOTAL CREDITS					**20**

(ECEL*: Course to be selected from the list of Program Electives)

Semester VII (Fourth year]
Branch/Course Electronics & Communication Engineering

Sr. No.	Course Code	Course Title	L	T	P	ContactHrs./wk.	Credits
1	ECEL*	Program Elective -3	3	0	0	4	3
2	ECEL*	Program Elective -4	3	0	0	4	3
3	ECEL*	Program Elective -5	3	0	0	3	3
4		OE-3	3	0	0	3	3
5	ECP1	Project Stage-I	0	0	10	10	5
6		Slot for HS/BS					4
		TOTAL CREDITS					**21**

(ECEL*: Course to be selected from the list of Program Electives)

Semester VIII(Fourth year]
Branch/Course Electronics & Communication Engineering

Sr. No.	Course Code	Course Title	L	T	P	Contacthrs. /wk.	Credits
1	ECEL*	Program Elective -6	3	0	0	3	3
2	ECEL*	Program Elective -7	3	0	0	3	3
3		OE-3	3	0	0	3	3
4		OE-4	3	0	0	3	3
5	ECP2	Project Stage-II	0	0	18	18	9
		TOTAL CREDITS					**21**

(ECEL*: Course to be selected from the list of Program Electives)

CHAPTER 2

DETAILED 4-YEAR CURRICULUM CONTENTS

Undergraduate Degree in Engineering & Technology

Branch/Course: ELECTORNICS & COMMUNICATION ENGINEERING

PROGRAM CORE COURSES

EC01	**Electronic Devices**	**3L:0T:0P**	**3 credits**

Introduction to Semiconductor Physics: Review of Quantum Mechanics, Electrons in periodic Lattices, E-k diagrams. Energy bands in intrinsic and extrinsic silicon; Carrier transport: diffusion current, drift current, mobility and resistivity; sheet resistance, design of resistors

Generation and recombination of carriers; Poisson and continuity equation P-N junction characteristics, I-Vcharacteristics, and small signal switching models; Avalanche breakdown, Zener diode, Schottky diode

Bipolar Junction Transistor, I-V characteristics, Ebers-Moll Model,MOS capacitor, C-V characteristics, MOSFET, I-V characteristics, and small signal models of MOS transistor, LED, photodiode and solar cell;

Integrated circuit fabrication process: oxidation, diffusion, ion implantation, photolithography, etching, chemical vapor deposition, sputtering, twin-tub CMOS process.

Text /Reference Books:

1. G. Streetman, and S. K. Banerjee, “Solid State Electronic Devices,” 7th edition, Pearson,2014.
2. D. Neamen , D. Biswas "Semiconductor Physics and Devices," McGraw-Hill Education
3. S. M. Sze and K. N. Kwok, “Physics of Semiconductor Devices,” 3rd edition, John Wiley &Sons, 2006.
4. C.T. Sah, “Fundamentals of solid state electronics,” World Scientific Publishing Co. Inc, 1991.
5. Y. Tsividis and M. Colin, “Operation and Modeling of the MOS Transistor,” Oxford Univ.Press, 2011.

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. Understand the principles of semiconductor Physics
2. Understand and utilize the mathematical models of semiconductor junctions andMOS transistors for circuits and systems.

EC02:Electronic Devices Lab (0L:0T:2P) (1 credit)

Hands-on experiments related to the course contents of EC01

EC03	**Digital System Design**	**3L:0T:0P**	**3 credits**

Logic Simplification and Combinational Logic Design: Review of Boolean Algebra and De Morgan'sTheorem, SOP & POS forms, Canonical forms, Karnaugh maps up to 6 variables, Binary codes, CodeConversion.

MSI devices like Comparators, Multiplexers, Encoder, Decoder, Driver & Multiplexed Display, Half andFull Adders, Subtractors, Serial and Parallel Adders, BCD Adder, Barrel shifter and ALU
Sequential Logic Design: Building blocks like S-R, JK and Master-Slave JK FF, Edge triggered FF, Rippleand Synchronous counters, Shift registers, Finite state machines, Design of synchronous FSM,Algorithmic State Machines charts. Designing synchronous circuits like Pulse train generator, PseudoRandom Binary Sequence generator, Clock generation

Logic Families and Semiconductor Memories: TTL NAND gate, Specifications, Noise margin, Propagation delay, fan-in, fan-out, Tristate TTL, ECL, CMOS families and their interfacing, Memory elements, Conceptof Programmable logic devices like FPGA. Logic implementation using Programmable Devices.

VLSI Design flow: Design entry: Schematic, FSM & HDL, different modeling styles in VHDL, Data typesand objects, Dataflow, Behavioral and Structural Modeling, Synthesis and Simulation VHDL constructs and codes for combinational and sequential circuits.

Text/Reference Books:

1. R.P. Jain, "Modern digital Electronics", Tata McGraw Hill, 4th edition, 2009.
2. Douglas Perry, "VHDL", Tata McGraw Hill, 4th edition, 2002.
3. W.H. Gothmann, "Digital Electronics- An introduction to theory and practice", PHI, 2nd edition ,2006.
4. D.V. Hall, "Digital Circuits and Systems", Tata McGraw Hill, 1989
5. Charles Roth, "Digital System Design using VHDL", Tata McGraw Hill 2nd edition 2012.

Course outcomes:

At the end of this course students will demonstrate the ability to

1. Design and analyze combinational logic circuits
2. Design & analyze modular combinational circuits with MUX/DEMUX, Decoder, Encoder
3. Design & analyze synchronous sequential logic circuits
4. Use HDL & appropriate EDA tools for digital logic design and simulation

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EC04: Digital System Design Laboratory[0L:0T:2P 1 credit]

Hands-on experiments related to the course contents EC03

EC05	**Signals and System**	**3L:0T:0P**	**3 credits**

Signals and systems as seen in everydaylife, and in various branches of engineering and science.

Energy and power signals, continuous and discrete time signals, continuous and discrete amplitude signals. System properties: linearity: additivity and homogeneity, shift-invariance, causality, stability, realizability.

Linear shift-invariant (LSI) systems, impulse response and step response, convolution, input-output behavior with aperiodic convergent inputs. Characterization of causality and stability of linear shift-invariant systems. System representation through differential equations and difference equations.

Periodic and semi-periodic inputs to an LSI system, the notion of a frequencyresponse and its relation to the impulse response, Fourier series representation, the Fourier Transform, convolution/multiplication and their effect in the frequency domain, magnitude and phase response, Fourier domain duality. The Discrete-Time Fourier Transform (DTFT) and the Discrete Fourier Transform (DFT). Parseval's Theorem.The idea of signal space and orthogonal bases,

The Laplace Transform, notion ofeigen functions of LSI systems, a basis of eigen functions, region of convergence, poles and zeros of system, Laplace domain analysis, solution to differential equations and system behavior.

The z-Transform for discrete time signals and systems- eigen functions, region of convergence, z-domain analysis.

State-space analysis and multi-input, multi-output representation. The state-transition matrix and its role. The Sampling Theorem and its implications- Spectra of sampled signals. Reconstruction: ideal interpolator, zero-order hold, first-order hold, and so on. Aliasing and its effects. Relation between continuous and discrete time systems.

Text/Reference books:

1. A.V. Oppenheim, A.S. Willsky and I.T. Young, "Signals and Systems", Prentice Hall, 1983.
2. R.F. Ziemer, W.H. Tranter and D.R. Fannin, "Signals and Systems - Continuous and Discrete", 4th edition, Prentice Hall, 1998.
3. Papoulis, "Circuits and Systems: A Modern Approach", HRW, 1980.
4. B.P. Lathi, "Signal Processing and Linear Systems", Oxford University Press, c1998.
5. Douglas K. Lindner, "Introduction to Signals and Systems", McGraw Hill International Edition: c1999.

6. Simon Haykin, Barry van Veen, "Signals and Systems", John Wiley and Sons (Asia) Private Limited, c1998.
7. Robert A. Gabel, Richard A. Roberts, "Signals and Linear Systems", John Wiley and Sons, 1995.
8. M. J. Roberts, "Signals and Systems - Analysis using Transform methods and MATLAB", TMH, 2003.
9. J. Nagrath, S. N. Sharan, R. Ranjan, S. Kumar, "Signals and Systems", TMH New Delhi, 2001.
10. Ashok Ambardar,"Analog and Digital Signal Processing", 2nd Edition, Brooks/ Cole Publishing Company (An international Thomson Publishing Company), 1999.

Course outcomes:
At the end of this course students will demonstrate the ability to

1. Analyze different types of signals
2. Represent continuous and discrete systems in time and frequency domain using different transforms
3. Investigate whether the system is stable
4. Sampling and reconstruction of a signal

EC06	**Network Theory**	**3L:0T:0P**	**3 credits**

Node and Mesh Analysis, matrix approach of network containing voltage and current sources, and reactances, source transformation and duality. Network theorems: Superposition, reciprocity, Thevenin’s, Norton’s, Maximum power Transfer, compensation and Tallegen's theorem as applied to AC. circuits. Trigonometric and exponential Fourier series: Discrete spectra and symmetry of waveform, steady state response of a network to non-sinusoidal periodic inputs, power factor, effective values, Fourier transform and continuous spectra, three phase unbalanced circuit and power calculation.

Laplace transforms and properties: Partial fractions, singularity functions, waveform synthesis, analysis of RC, RL, and RLC networks with and without initial conditions with Laplace transforms evaluation of initial conditions.

Transient behavior, concept of complex frequency, Driving points and transfer functions poles and zeros of immittance function, their properties, sinusoidal response from pole-zero locations, convolution theorem and Two four port network and interconnections, Behaviors of series and parallel resonant circuits, Introduction to band pass, low pass, high pass and band reject filters.

Text/Reference Books

1. Van, Valkenburg.; “Network analysis”; Prentice hall of India, 2000
2. Sudhakar, A., Shyammohan, S. P.; “Circuits and Network”; Tata McGraw-Hill New Delhi, 1994
3. A William Hayt, “Engineering Circuit Analysis” 8th Edition, McGraw-Hill Education

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. Understand basics electrical circuits with nodal and mesh analysis.
2. Appreciate electrical network theorems.
3. Apply Laplace Transform for steady state and transient analysis.
4. Determine different network functions.
5. Appreciate the frequency domain techniques.

EC07	Analog and Digital Communication	3L:0T:0P	3 credits

Review of signals and systems, Frequency domain representation of signals, Principles of AmplitudeModulation Systems- DSB, SSB and VSB modulations. Angle Modulation, Representation of FM and PM signals, Spectral characteristics of angle modulated signals.

Review of probability and random process. Gaussian and white noise characteristics,Noise in amplitude modulation systems, Noise in Frequency modulation systems. Pre-emphasis and De-emphasis, Threshold effect in angle modulation.

Pulse modulation. Sampling process. Pulse Amplitude and Pulse code modulation (PCM),Differential pulse code modulation. Delta modulation, Noise considerations in PCM, Time Division multiplexing, Digital Multiplexers.

Elements of Detection Theory, Optimum detection of signals in noise,Coherent communication with waveforms- Probability of Error evaluations. BasebandPulse Transmission- Inter symbol Interference and Nyquist criterion.Pass band Digital Modulation schemes- Phase Shift Keying, Frequency Shift Keying,Quadrature Amplitude Modulation, Continuous Phase Modulation and Minimum Shift Keying.

Digital Modulation tradeoffs. Optimum demodulation of digital signals over band-limited channels- Maximum likelihood sequence detection (Viterbi receiver). Equalization Techniques. Synchronization and Carrier Recovery for Digital modulation.

Text/Reference Books:

1. Haykin S., "Communications Systems", John Wiley and Sons, 2001.
2. Proakis J. G. and Salehi M., "Communication Systems Engineering", Pearson Education, 2002.
3. Taub H. and Schilling D.L., "Principles of Communication Systems”, Tata McGraw Hill, 2001.
4. Wozencraft J. M. and Jacobs I. M., ``Principles of Communication Engineering",John Wiley, 1965.
5. Barry J. R., Lee E. A. and Messerschmitt D. G., ``Digital Communication", Kluwer Academic Publishers, 2004.
6. Proakis J.G., ``Digital Communications", 4th Edition, McGraw Hill, 2000.

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. Analyze and compare different analog modulation schemes for their efficiency and bandwidth
2. Analyze the behavior of a communication system in presence of noise
3. Investigate pulsed modulation system and analyze their system performance
4. Analyze different digital modulation schemes and can compute the bit error performance

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EC08: Analog and Digital Communication Laboratory[0L:0T:2P 1 credit]

Hands-on experiments related to the course contents EC07

EC09	**Analog circuits**	**3L:0T:0P**	**3 credits**

Diode Circuits, Amplifiermodels: Voltage amplifier, current amplifier, trans-conductance amplifier and trans-resistance amplifier. Biasing schemes for BJT and FET amplifiers, bias stability, various configurations (such as CE/CS, CB/CG, CC/CD) and their features, small signal analysis, low frequency transistor models, estimation of voltage gain, input resistance, output resistance etc., design procedure for particular specifications, low frequency analysis of multistage amplifiers.

High frequency transistor models, frequency response of single stage andmultistage amplifiers, cascode amplifier. Various classes of operation (Class A, B, AB, C etc.), their power efficiency and linearity issues. Feedback topologies: Voltage series, current series, voltage shunt, current shunt, effect of feedback on gain, bandwidth etc., calculation with practical circuits, concept of stability, gain margin and phase margin.

Oscillators: Review of the basic concept, Barkhausen criterion, RC oscillators(phase shift, Wien bridge etc.), LC oscillators (Hartley, Colpitt, Clapp etc.), non-sinusoidal oscillators.
Current mirror: Basic topology and its variants, V-I characteristics, outputresistance and minimum sustainable voltage (VON), maximum usable load. Differential amplifier: Basic structure and principle of operation, calculation of differential gain, common mode gain, CMRR and ICMR. OP-AMP design: design of differential amplifier for a given specification, design of gain stages and output stages, compensation.

OP-AMP applications: review of inverting and non-inverting amplifiers, integratorand differentiator, summing amplifier, precision rectifier, Schmitt trigger and its applications. Active filters: Low pass, high pass, band pass and band stop, design guidelines.

Digital-to-analog converters (DAC): Weighted resistor, R-2R ladder, resistorstring etc. Analog-to-digital converters (ADC): Single slope, dual slope, successive approximation, flash etc.

Switched capacitor circuits: Basic concept, practical configurations, application in amplifier, integrator, ADC etc.

Text/Reference Books:

1. J.V. Wait, L.P. Huelsman and GA Korn, Introduction to Operational Amplifier theory and applications, McGraw Hill, 1992.
2. J. Millman and A. Grabel, Microelectronics, 2nd edition, McGraw Hill, 1988.
3. P. Horowitz and W. Hill, The Art of Electronics, 2nd edition, Cambridge University Press, 1989.
4. A.S. Sedra and K.C. Smith, Microelectronic Circuits, Saunder's College11
5. Publishing, Edition IV
6. Paul R. Gray and Robert G.Meyer, Analysis and Design of Analog Integrated Circuits, John Wiley, 3rd Edition

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. Understand the characteristics of diodes and transistors
2. Design and analyze various rectifier and amplifier circuits
3. Design sinusoidal and non-sinusoidal oscillators
4. Understand the functioning of OP-AMP and design OP-AMP based circuits
5. Design ADC and DAC

EC10: Analog Circuit Laboratory[0L:0T:2P 1 credit]

Hands-on experiments related to the course contents EC09

EC11	Microcontrollers	3L:0T:0P	3 credits

Overview of microcomputer systems and their building blocks, memoryinterfacing, concepts of interrupts and Direct Memory Access, instruction sets of microprocessors (with examples of 8085 and 8086);

Interfacing with peripherals - timer, serial I/O, parallel I/O, A/D and D/Aconverters;Arithmetic Coprocessors; System level interfacing design;

Concepts of virtual memory, Cache memory, Advanced coprocessorArchitectures- 286, 486, Pentium; Microcontrollers: 8051 systems,

Introduction to RISC processors; ARM microcontrollers interface designs.

Text/Reference Books:

1. R. S. Gaonkar, Microprocessor Architecture: Programming and Applications with the 8085/8080A, Penram International Publishing, 1996

2. D A Patterson and J H Hennessy, "Computer Organization and Design The hardware and software interface. Morgan Kaufman Publishers.
3. Douglas Hall, Microprocessors Interfacing, Tata McGraw Hill, 1991.
4. Kenneth J. Ayala, The 8051 Microcontroller, Penram International Publishing, 1996.

Course Outcomes:
At the end of this course students will demonstrate the ability to
1. Do assembly language programming
2. Do interfacing design of peripherals like, I/O, A/D, D/A, timer etc.
3. Develop systems using different microcontrollers
4. Understand RSIC processors and design ARM microcontroller based systems

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EC12: Microcontroller Lab[0L:0T:2P 1 credit]

Hands-on experiments related to the course contents EC11

EC13	Electromagnetic Waves	3L:0T:0P	3 credits

Transmission Lines- Equations of Voltage and Current on TX line, Propagationconstant and characteristic impedance, and reflection coefficient and VSWR, Impedance Transformation on Loss-less and Low loss Transmission line, Power transfer on TX line, Smith Chart, Admittance Smith Chart, Applications of transmission lines: Impedance Matching, use transmission line sections as circuit elements.

Maxwell’s Equations- Basics of Vectors, Vector calculus, Basic laws ofElectromagnetics, Maxwell's Equations, Boundary conditions at Media Interface.

Uniform Plane Wave- Uniform plane wave, Propagation of wave, Wavepolarization, Poincare’s Sphere, Wave propagation in conducting medium, phase and group velocity, Power flow and Poynting vector, Surface current and power loss in a conductor

Plane Waves at a Media Interface- Plane wave in arbitrary direction, Reflection and refraction at dielectric interface, Total internal reflection, wave polarization at media interface, Reflection from a conducting boundary.

Wave propagation in parallel planewaveguide, Analysis of waveguide general approach, Rectangular waveguide, Modal propagation in rectangular waveguide, Surface currents on the waveguide walls, Field visualization, Attenuation in waveguide.

Radiation: Solution for potential function, Radiation from the Hertz dipole, Powerradiated by hertz dipole, Radiation Parameters of antenna, receiving antenna, Monopole and Dipole antenna,

Text/Reference Books:

1. R.K. Shevgaonkar, Electromagnetic Waves, Tata McGraw Hill India, 2005
2. E.C. Jordan & K.G. Balmain, Electromagnetic waves & Radiating Systems, Prentice Hall, India
3. Narayana Rao, N: Engineering Electromagnetics, 3rd ed., Prentice Hall, 1997.
4. David Cheng, Electromagnetics, Prentice Hall

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. Understand characteristics and wave propagation on high frequency transmission lines
2. Carryout impedance transformation on TL
3. Use sections of transmission line sections for realizing circuit elements
4. Characterize uniform plane wave
5. Calculate reflection and transmission of waves at media interface
6. Analyze wave propagation on metallic waveguides in modal form
7. Understand principle of radiation and radiation characteristics of an antenna

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EC14: Electromagnetic Waves Lab[0L:0T:2P 1 credit]

Hands-on experiments related to the course contents EC13

EC15	**Computer Architecture**	**3L:0T:0P**	**3 credits**

Basic Structure of Computers, Functional units, software, performance issues software, machine instructions and programs, Types of instructions, Instruction sets: Instruction formats, Assembly language, Stacks, Ques, Subroutines.

Processor organization, Information representation, number formats.

Multiplication & division, ALU design, Floating Point arithmetic, IEEE 754 floating point formats

Control Design, Instruction sequencing, Interpretation, Hard wired control - Design methods, and CPU control unit. Microprogrammed Control - Basic concepts, minimizing microinstruction size, multiplier control unit. Microprogrammed computers - CPU control unit

Memory organization, device characteristics, RAM, ROM, Memory management, Concept of Cache & associative memories, Virtual memory.

System organization, Input - Output systems, Interrupt, DMA, Standard I/O interfaces

Concept of parallel processing, Pipelining, Forms of parallel processing, interconnect network

Text/Reference Books:

1. V.Carl Hammacher, “Computer Organisation”, Fifth Edition.
2. A.S.Tanenbum, “Structured Computer Organisation”, PHI, Third edition
3. Y.Chu, "Computer Organization and Microprogramming”, II, Englewood Chiffs, N.J., Prentice Hall Edition
4. M.M.Mano, “Computer System Architecture”, Edition
5. C.W.Gear, “Computer Organization and Programming”, McGraw Hill, N.V. Edition
6. Hayes J.P, “Computer Architecture and Organization”, PHI, Second edition

Course Outcomes

At the end of this course students will demonstrate the ability to

1. learn how computers work
2. know basic principles of computer’s working
3. analyze the performance of computers
4. know how computers are designed and built
5. Understand issues affecting modern processors (caches, pipelines etc.).

EC16	**Probability and Stochastic Processes**	**3L:0T:0P**	**3 credits**

Sets and set operations; Probability space; Conditional probability and Bayes theorem;Combinatorial probability and sampling models.

Discrete random variables, probability mass function, probability distribution function,example random variables and distributions; Continuous random variables, probability density function, probability distribution function, example distributions;

Joint distributions, functions of one and two random variables, moments of randomvariables; Conditional distribution, densities and moments; Characteristic functions of a random variable; Markov, Chebyshev and Chernoff bounds;

Random sequences and modes of convergence (everywhere, almost everywhere,probability, distribution and mean square); Limit theorems; Strong and weak laws of large numbers, central limit theorem.

Random process. Stationary processes. Mean and covariance functions. Ergodicity.Transmission of random process through LTI. Power spectral density.

Text/Reference Books:

1. H. Stark and J. Woods, ``Probability and Random Processes with Applications to Signal Processing," Third Edition, Pearson Education
2. A.Papoulis and S. Unnikrishnan Pillai, ``Probability, Random Variables and Stochastic Processes," Fourth Edition, McGraw Hill.
3. K. L. Chung, Introduction to Probability Theory with Stochastic Processes, Springer International
4. P. G. Hoel, S. C. Port and C. J. Stone, Introduction to Probability, UBS Publishers,
5. P. G. Hoel, S. C. Port and C. J. Stone, Introduction to Stochastic Processes, UBS Publishers
6. S. Ross, Introduction to Stochastic Models, Harcourt Asia, Academic Press.

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. Understand representation of random signals
2. Investigate characteristics of random processes
3. Make use of theorems related to random signals
4. To understand propagation of random signals in LTI systems.

EC17	**Digital Signal Processing**	**3L:0T:0P**	**3 credits**

Discrete time signals: Sequences; representation of signals on orthogonal basis; Samplingand reconstruction of signals;Discrete systems attributes, Z-Transform, Analysis of LSI systems, frequencyAnalysis, Inverse Systems, Discrete Fourier Transform (DFT),Fast Fourier Transform Algorithm, Implementation of Discrete Time Systems

Designof FIR Digital filters: Windowmethod,Park-McClellan's method.Design of IIR Digital Filters: Butterworth, Chebyshev and Elliptic Approximations;Lowpass, Bandpass, Bandstop and High pass filters.

Effect of finite register length in FIR filter design.Parametric and non-parametric spectral estimation. Introduction to multirate signalprocessing.
Application of DSP.

Text/Reference Books:

1. S.K.Mitra, Digital Signal Processing: A computer based approach.TMH
2. A.V. Oppenheim and Schafer, Discrete Time Signal Processing, Prentice Hall, 1989.
3. John G. Proakis and D.G. Manolakis, Digital Signal Processing: Principles, Algorithms And Applications, Prentice Hall, 1997.
4. L.R. Rabiner and B. Gold, Theory and Application of Digital Signal Processing, Prentice Hall, 1992.
5. J.R. Johnson, Introduction to Digital Signal Processing, Prentice Hall, 1992.
6. D.J.DeFatta, J. G. Lucas andW.S.Hodgkiss, Digital Signal Processing, John Wiley& Sons, 1988.

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. Represent signals mathematically in continuous and discrete time and frequency domain
2. Get the response of an LSI system to different signals
3. Design of different types of digital filters for various applications

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EC18: Digital Signal Processing Laboratory [0L:0T:2P 1 credit]

Hands-on experiments related to the course contents EC17

EC19	Control Systems	3L:0T:0P	3 credits

Introduction to control problem- Industrial Control examples. Transfer function. System with dead-time. System response. Control hardware and their models: potentiometers, synchros, LVDT, dc and ac servomotors, tacho-generators, electro hydraulic valves, hydraulic servomotors, electro pneumatic valves, pneumatic actuators. Closed-loop systems. Block diagram and signal flow graph analysis.

Feedback control systems- Stability, steady-state accuracy,transient accuracy, disturbance rejection, insensitivity and robustness. proportional, integral and derivative systems. Feed-forward and multi-loop control configurations, stability concept, relative stability, Routh stability criterion.

Time response of second-order systems, steady-state errors and error constants. Performance specifications in time-domain. Root locus method of design. Lead and lag compensation.

Frequency-response analysis- Polar plots, Bode plot, stability in frequency domain, Nyquist plots. Nyquist stability criterion. Performance specifications in frequency-domain. Frequency-domain methods of design, Compensation & their realization in time & frequency domain. Lead and Lag compensation. Op-amp based and digital implementation of compensators. Tuning of process controllers. State variable formulation and solution.

State variable Analysis- Concepts of state, state variable, state model, state modelsfor linear continuous time functions, diagonalization of transfer function, solution of state equations, concept of controllability & observability.

Introduction to Optimal control & Nonlinear control, Optimal Control problem,Regulator problem, Output regulator, treking problem. Nonlinear system – Basic concept & analysis.

Text/Reference Books:

1. Gopal. M., “Control Systems: Principles and Design”, Tata McGraw-Hill, 1997.
2. Kuo, B.C., “Automatic Control System”, Prentice Hall, sixth edition, 1993.
3. Ogata, K., “Modern Control Engineering”, Prentice Hall, second edition, 1991.

4. Nagrath & Gopal, “Modern Control Engineering”, New Age International, New Delhi

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. Characterize a system and find its study state behavior
2. Investigate stability of a system using different tests
3. Design various controllers
4. Solve liner, non-liner and optimal control problems

EC20	**Computer Network**	**3L:0T:0P**	**3 credits**

Introduction to computer networks and the Internet: Application layer: Principles of network applications, The Web and Hyper Text Transfer Protocol, File transfer, Electronic ail, Domain name system, Peer-to-Peer file sharing, Socket programming, Layering concepts.

Switching in networks: Classification and requirements of switches, a generic switch, Circuit Switching, Time-division switching, Space-division switching, Crossbar switch and evaluation of blocking probability, 2-stage, 3-stage and n-stage networks, Packet switching, Blocking in packet switches, Three generations of packet switches, switch fabric, Buffering, Multicasting, Statistical

Multiplexing. Transport layer: Connectionless transport - User Datagram Protocol, Connection-oriented transport – Transmission Control Protocol, Remote Procedure Call.

Transport layer: Connectionless transport - User Datagram Protocol, Connection-oriented transport – Transmission Control Protocol, Remote Procedure Call.

Congestion Control and Resource Allocation: Issues in Resource Allocation, Queuing Disciplines,

TCP congestion Control, Congestion Avoidance Mechanisms and Quality of Service.

Network layer: Virtual circuit and Datagram networks, Router, Internet Protocol, Routing algorithms, Broadcast and Multicast routing

Link layer: ALOHA, Multiple access protocols, IEEE 802 standards, Local Area Networks, addressing, Ethernet, Hubs, Switches.

Text Reference books:

1. J.F. Kurose and K. W. Ross, “Computer Networking – A top down approach featuring the Internet”, Pearson Education, 5th Edition
2. L. Peterson and B. Davie, “Computer Networks – A Systems Approach” Elsevier Morgan Kaufmann Publisher, 5th Edition.
3. T. Viswanathan, “Telecommunication Switching System and Networks”, Prentice Hall
4. S. Keshav, “An Engineering Approach to Computer Networking” , Pearson Education

5. B. A. Forouzan, "Data Communications and Networking", Tata McGraw Hill, 4th Edition
6. Andrew Tanenbaum, "Computer networks", Prentice Hall
7. D. Comer, "Computer Networks and Internet/TCP-IP", Prentice Hall
8. William Stallings, "Data and computer communications", Prentice Hall

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Understand the concepts of networking thoroughly.
2. Design a network for a particular application.
3. Analyze the performance of the network.

EC21:Computer Network Laboratory[0L:0T:4P 2 credits]

Hands-on experiments related to the course contents EC20

EC22	Electronics Measurement Lab	0L:0T:2P	1 credit

List of Experiments

1. Designing DC bridge for Resistance Measurement (Quarter, Half and Full bridge)
2. Designing AC bridge Circuit for capacitance measurement
3. Designing signal Conditioning circuit for Pressure Measurement
4. Designing signal Conditioning circuit for Temperature Measurement
5. Designing signal Conditioning circuit for Torque Measurement
6. Designing signal Conditioning circuit for Strain Measurement
7. Experimental study for the characteristics of ADC and DAC
8. Error compensation study using Numerical analysis using MATLAB (regression)

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. Design and validate DC and AC bridges
2. Analyze the dynamic response and the calibration of few instruments
3. Learn about various measurement devices, their characteristics, their operation and their limitations
4. understand statistical data analysis
5. Understand computerized data acquisition.

EC23	**Mini Project/Electronic Design workshop**	**0L:0T:4P**	**2 credits**

Guidelines:

1. The mini-project is a team activity having 3-4 students in a team. This is electronic product design work with a focus on electronic circuit design.
2. The mini project may be a complete hardware or a combination of hardware and software. The software part in mini project should be less than 50% of the total work.
3. Mini Project should cater to a small system required in laboratory or real life.
4. It should encompass components, devices, analog or digital ICs, micro controller with which functional familiarity is introduced.
5. After interactions with course coordinator and based on comprehensive literature survey/ need analysis, the student shall identify the title and define the aim and objectives of mini-project.
6. Student is expected to detail out specifications, methodology, resources required, critical issues involved in design and implementation and submit the proposal within first week of the semester.
7. The student is expected to exert on design, development and testing of the proposed work as per the schedule.
8. Art work and Layout should be made using CAD based PCB simulation software. Due considerations should be given for power requirement of the system, mechanical aspects for enclosure and control panel design.
9. Completed mini project and documentation in the form of mini project report is to be submitted at the end of semester.

10. The tutorial sessions should be used for discussion on standard practices used for electronic circuits/product design, converting the circuit design into a complete electronic product, PCB design using suitable simulation software, estimation of power budget analysis of the product, front panel design and mechanical aspects of the product, and guidelines for documentation /report writing.

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

1. Conceive a problem statement either from rigorous literature survey or from the requirements raised from need analysis.
2. Design, implement and test the prototype/algorithm in order to solve the conceived problem.
3. Write comprehensive report on mini project work.

PROGRAM ELECTIVE COURSES

ECEL01	Microwave Theory and Techniques	3L:0T:0P	3 credits

Introduction to Microwaves-History of Microwaves, Microwave Frequency bands;Applications of Microwaves: Civil and Military, Medical, EMI/ EMC.

Mathematical Model of Microwave Transmission-Concept of Mode, Features ofTEM, TE and TM Modes, Losses associated with microwave transmission, Concept of Impedance in Microwave transmission.

Analysis of RF and Microwave Transmission Lines- Coaxial line, Rectangularwaveguide, Circular waveguide, Strip line, Micro strip line.

Microwave Network Analysis- Equivalent voltages and currents for non-TEMlines, Network parameters for microwave circuits, Scattering Parameters.

Passive and Active Microwave Devices- Microwave passive components:Directional Coupler, Power Divider, Magic Tee, Attenuator, Resonator. Microwave active components: Diodes, Transistors, Oscillators, Mixers. Microwave Semiconductor Devices: Gunn Diodes, IMPATT diodes, Schottky Barrier diodes, PIN diodes. Microwave Tubes: Klystron, TWT, Magnetron.

Microwave Design Principles- Impedance transformation, Impedance Matching,Microwave Filter Design, RF and Microwave Amplifier Design, Microwave Power Amplifier Design, Low Noise Amplifier Design, Microwave Mixer Design, Microwave Oscillator Design. Microwave Antennas- Antenna parameters, Antenna for ground based systems, Antennas for airborne and satellite borne systems, Planar Antennas.

Microwave Measurements- Power, Frequency and impedance measurement atmicrowave frequency, Network Analyzer and measurement of scattering parameters, Spectrum Analyzer and measurement of spectrum of a microwave signal, Noise at microwave frequency and measurement of noise figure. Measurement of Microwave antenna parameters.

Microwave Systems- Radar, Terrestrial and Satellite Communication, Radio Aidsto Navigation, RFID, GPS. Modern Trends in Microwaves Engineering- Effect of Microwaves on human body, Medical and Civil applications of microwaves, Electromagnetic interference and Electromagnetic Compatibility (EMI & EMC), Monolithic Microwave ICs, RFMEMS for microwave components, Microwave Imaging.

Text/Reference Books:

1. R.E. Collins, Microwave Circuits, McGraw Hill
2. K.C. Gupta and I.J. Bahl, Microwave Circuits, Artech house

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

1. Understand various microwave system components their properties.
2. Appreciate that during analysis/ synthesis of microwave systems, the different mathematical treatment is required compared to general circuit analysis.
3. Design microwave systems for different practical application.

ECEL02	Fiber Optic Communication	3L:0T:0P	3 credits

Introduction to vector nature of light, propagation of light, propagation of light ina cylindrical dielectric rod, Ray model, wave model.

Different types of optical fibers, Modal analysis of a step index fiber.
Signaldegradation on optical fiber due to dispersion and attenuation. Fabrication of fibers and measurement techniques like OTDR.

Optical sources - LEDs and Lasers, Photo-detectors - pin-diodes, APDs, detectorresponsivity, noise, optical receivers. Optical link design - BER calculation, quantum limit, power penalties.

Optical switches - coupled mode analysis of directional couplers, electro-opticswitches.

Optical amplifiers - EDFA, Raman amplifier.

WDM and DWDM systems. Principles of WDM networks.

Nonlinear effects in fiber optic links. Concept of self-phase modulation, groupvelocity dispersion and solition based communication.

Text/Reference Books

1. J. Keiser, Fibre Optic communication, McGraw-Hill, 5th Ed. 2013 (Indian Edition).
2. T. Tamir, Integrated optics, (Topics in Applied Physics Vol.7), Springer-Verlag, 1975.
3. J. Gowar, Optical communication systems, Prentice Hall India, 1987.
4. S.E. Miller and A.G. Chynoweth, eds., Optical fibres telecommunications, Academic Press, 1979.
5. G. Agrawal, Nonlinear fibre optics, Academic Press, 2nd Ed. 1994.
6. G. Agrawal, Fiber optic Communication Systems, John Wiley and sons, New York, 1997
7. F.C. Allard, Fiber Optics Handbook for engineers and scientists, McGraw Hill, New York (1990).

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

1. Understand the principles fiber-optic communication, the components and the bandwidth advantages.

2. Understand the properties of the optical fibers and optical components.
3. Understand operation of lasers, LEDs, and detectors
4. Analyze system performance of optical communication systems
5. Design optical networks and understand non-linear effects in optical fibers

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ECEL03	**Information Theory and Coding**	**3L:0T:0P**	**3 credits**

Basics of information theory, entropy for discrete ensembles; Shannon's noiseless codingtheorem; Encoding of discrete sources.

Markov sources; Shannon's noisy coding theorem and converse for discrete channels;Calculation of channel capacity and bounds for discrete channels; Application to continuous channels.

Techniques of coding and decoding; Huffman codes and uniquely detectable codes;Cyclic codes, convolutional arithmetic codes.

Text/Reference Books:

1. N. Abramson, Information and Coding, McGraw Hill, 1963.
2. M. Mansurpur, Introduction to Information Theory, McGraw Hill, 1987.
3. R.B. Ash, Information Theory, Prentice Hall, 1970.
4. Shu Lin and D.J. Costello Jr., Error Control Coding, Prentice Hall, 1983.

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

1. Understand the concept of information and entropy
2. Understand Shannon’s theorem for coding
3. Calculation of channel capacity
4. Apply coding techniques

ECEL04	**Speech and Audio Processing**	**3L:0T:0P**	**3 credits**

Introduction- Speech production and modeling - Human Auditory System;General structure of speech coders; Classification of speech coding techniques – parametric, waveform and hybrid ; Requirements of speech codecs –quality, coding delays, robustness.

Speech Signal Processing- Pitch-period estimation, all-pole and all-zero filters,convolution; Power spectral density, periodogram, autoregressive model, autocorrelation estimation.

Linear Prediction of Speech- Basic concepts of linear prediction; LinearPrediction Analysis of non-stationary signals –prediction gain, examples; Levinson-Durbin algorithm; Long term and short-term linear prediction models; Moving average prediction.

Speech Quantization- Scalar quantization–uniform quantizer, optimum quantizer,logarithmic quantizer, adaptive quantizer, differential quantizers; Vector quantization – distortion measures, codebook design, codebook types.

Scalar Quantization of LPC- Spectral distortion measures, Quantization based onreflection coefficient and log area ratio, bit allocation; Line spectral frequency – LPC to LSF conversions, quantization based on LSF.

Linear Prediction Coding- LPC model of speech production; Structures of LPCencoders and decoders; Voicing detection; Limitations of the LPC model.

Code Excited Linear Prediction-CELP speech production model; Analysis-by-synthesis; Generic CELP encoders and decoders; Excitation codebook search – state-save method, zero-input zero-state method; CELP based on adaptive codebook, Adaptive Codebook search; Low Delay CELP and algebraic CELP.

Speech Coding Standards-An overview of ITU-T G.726, G.728 and G.729standards

Text/Reference Books:

1. “Digital Speech” by A.M.Kondoz, Second Edition (Wiley Students *Edition), 2004.*
2. “Speech Coding Algorithms: Foundation and Evolution of Standardized Coders”, W.C. Chu, WileyInter science, 2003.

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

1. Mathematically model the speech signal
2. Analyze the quality and properties of speech signal.
3. Modify and enhance the speech and audio signals.

ECEL05	**Introduction to MEMS**	**3L:0T:0P**	**3 credits**

Introduction and Historical Background, Scaling Effects. Micro/Nano Sensors, Actuators and Systems overview: Case studies. Review of Basic MEMS fabrication modules: Oxidation, Deposition Techniques, Lithography (LIGA), and Etching. Micromachining: Surface Micromachining, sacrificial layer processes, Stiction; Bulk
Micromachining, Isotropic Etching and Anisotropic Etching, Wafer Bonding. Mechanics of solids in MEMS/NEMS: Stresses, Strain, Hookes’s law, Poisson effect, Linear
Thermal Expansion, Bending; Energy methods, Overview of Finite Element Method, Modeling of Coupled Electromechanical Systems.

Text/Reference Book:

1. G. K. Ananthasuresh, K. J. Vinoy, S. Gopalkrishnan K. N. Bhat, V. K. Aatre, Micro and Smart Systems, Wiley India, 2012.
2. S. E.Lyshevski, Nano-and Micro-Electromechanical systems: Fundamentals of Nano-and Microengineering (Vol. 8). CRC press, (2005).
3. S. D. Senturia, Microsystem Design, Kluwer Academic Publishers, 2001.
4. M. Madou, Fundamentals of Microfabrication, CRC Press, 1997.
5. G. Kovacs, Micromachined Transducers Sourcebook, McGraw-Hill, Boston, 1998.
6. M.H. Bao, Micromechanical Transducers: Pressure sensors, accelerometers, and Gyroscopes, Elsevier, New York, 2000.

Course Outcomes:

At the end of the course the students will be able to

1. Appreciate the underlying working principles of MEMS and NEMS devices.
2. Design and model MEM devices.

ECEL06	**Adaptive Signal Processing**	**3L:0T:0P**	**3 credits**

General concept of adaptive filtering and estimation, applications and motivation, Review of probability, random variables and stationary random processes, Correlation structures, properties of correlation matrices.

Optimal FIR (Wiener) filter, Method of steepest descent, extension to complexvalued The LMS algorithm (real, complex), convergence analysis, weight errorcorrelation matrix, excess mean square error and mis-adjustment

Variants of the LMS algorithm: the sign LMS family, normalized LMSalgorithm, block LMS and FFT based realization, frequency domain adaptive filters, Sub-band adaptive filtering.
Signal space concepts - introduction to finite dimensional vectorspace theory, subspace, basis, dimension, linear operators, rank and nullity, inner product space, orthogonality, Gram-Schmidt orthogonalization, concepts of orthogonal projection,orthogonal decomposition of vector spaces.

Vector space of random variables, correlation as inner product, forward andbackward projections, Stochastic lattice filters, recursive updating of forward and backward prediction errors, relationship with AR modeling, joint process estimator, gradient adaptive lattice.

Introduction to recursive least squares (RLS), vector space formulation of RLSestimation, pseudo-inverse of a matrix, time updating of inner products, development of RLS lattice filters, RLS transversal adaptive filters. Advanced topics: affine projection and subspace based adaptive filters, partial update algorithms, QR decomposition and systolic array.

Text/Reference Books:

1. S. Haykin, Adaptive filter theory, Prentice Hall, 1986.
2. C.Widrow and S.D. Stearns, Adaptive signal processing, Prentice Hall, 1984.

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

1. Understand the non-linear control and the need and significance of changing the control parameters w.r.t. real-time situation.
2. Mathematically represent the 'adaptability requirement'.
3. Understand the mathematical treatment for the modeling and design of the signal processing systems.

ECEL07	**Antennas and Propagation**	**3L:0T:0P**	**3 credits**

Fundamental Concepts- Physical concept of radiation, Radiation pattern, near-andfar-field regions, reciprocity, directivity and gain, effective aperture, polarization, input impedance, efficiency, Friis transmission equation, radiation integrals and auxiliary potential functions.

Radiation from Wires and Loops- Infinitesimal dipole, finite-length dipole, linearelements near conductors, dipoles for mobile communication, small circular loop.

Aperture and Reflector Antennas- Huygens' principle, radiation from rectangularand circular apertures, design considerations, Babinet's principle, Radiation from sectoral and pyramidal horns, design concepts, prime-focus parabolic reflector and cassegrain antennas.

Broadband Antennas- Log-periodic and Yagi-Uda antennas, frequencyindependent antennas, broadcast antennas.

Micro strip Antennas- Basic characteristics of micro strip antennas, feedingmethods, methods of analysis, design of rectangular and circular patch antennas.

Antenna Arrays- Analysis of uniformly spaced arrays with uniform and non-uniform excitation amplitudes, extension to planar arrays, synthesis of antenna arrays using Schelkunoff polynomial method, Woodward-Lawson method.

Basic Concepts of Smart Antennas- Concept and benefits of smart antennas, fixedweight beam forming basics, Adaptive beam forming.

Different modes of Radio Wave propagation used in current practice.

Text/Reference Books:

1. J.D. Kraus, Antennas, McGraw Hill, 1988.
2. C.A. Balanis, Antenna Theory - Analysis and Design, John Wiley, 1982.

3. R.E. Collin, Antennas and Radio Wave Propagation, McGraw Hill, 1985.
4. R.C. Johnson and H. Jasik, Antenna Engineering Handbook, McGraw ill, 1984.
5. I.J. Bahl and P. Bhartia, Micro Strip Antennas, Artech House, 1980.
6. R.K. Shevgaonkar, Electromagnetic Waves, Tata McGraw Hill, 2005
7. R.E. Crompton, Adaptive Antennas, John Wiley

Course Outcomes:
At the end of the course, students will demonstrate the ability to:

1. Understand the properties and various types of antennas.
2. Analyze the properties of different types of antennas and their design.
3. Operate antenna design software tools and come up with the design of the antenna of required specifications.

ECEL08	Bio-Medical Electronics	3L:0T:0P	3 credits

Brief introduction to human physiology. Biomedical transducers: displacement,velocity, force, acceleration, flow, temperature, potential, dissolved ions and gases. Bio-electrodes and bio-potential amplifiers for ECG, EMG, EEG, etc.

Measurement of blood temperature, pressure and flow. Impedanceplethysmography. Ultrasonic, X-ray and nuclear imaging.Prostheses and aids: pacemakers, defibrillators, heart-lung machine, artificialkidney, aids for the handicapped. Safety aspects.

Text/Reference Books:

1. W.F. Ganong, Review of Medical Physiology, 8th Asian Ed, Medical Publishers, 1977.
2. J.G. Websster, ed., Medical Instrumentation, Houghton Mifflin, 1978.
3. A.M. Cook and J.G. Webster, eds., Therapeutic Medical Devices, Prentice-Hall, 1982.

Course Outcomes:
At the end of the course, students will demonstrate the ability to:

1. Understand the application of the electronic systems in biological and medical applications.
2. Understand the practical limitations on the electronic components while handling bio-substances.
3. Understand and analyze the biological processes like other electronic processes.

ECEL09	Mobile Communication and Networks	3L:0T:0P	3 credits

Cellular concepts- Cell structure, frequency reuse, cell splitting, channelassignment, handoff, interference, capacity, power control; Wireless Standards: Overview of 2G and 3G cellular standards.

Signal propagation-Propagation mechanism- reflection, refraction, diffraction andscattering, large scale signal propagation and lognormal shadowing. Fading channels-Multipath and small scale fading- Doppler shift, statistical multipath channel models, narrowband and wideband fading models, power delay profile, average and rms delay spread, coherence bandwidth and coherence time, flat and frequency selective fading, slow and fast fading, average fade duration and level crossing rate.

Capacity of flat and frequency selective channels. Antennas- Antennas for mobileterminal- monopole antennas, PIFA, base station antennas and arrays.

Multiple access schemes-FDMA, TDMA, CDMA and SDMA. Modulationschemes- BPSK, QPSK and variants, QAM, MSK and GMSK, multicarrier modulation, OFDM.

Receiver structure- Diversity receivers- selection and MRC receivers, RAKEreceiver, equalization: linear-ZFE and adaptive, DFE. Transmit diversity-Altamonte scheme.

MIMO and space time signal processing, spatial multiplexing, diversity/multiplexing tradeoff.Performance measures- Outage, average snr, average symbol/bit error rate. System examples- GSM, EDGE, GPRS, IS-95, CDMA 2000 and WCDMA.

Text/Reference Books:

1. WCY Lee, Mobile Cellular Telecommunications Systems, McGraw Hill, 1990.
2. WCY Lee, Mobile Communications Design Fundamentals, Prentice Hall, 1993.
3. Raymond Steele, Mobile Radio Communications, IEEE Press, New York, 1992.
4. AJ Viterbi, CDMA: Principles of Spread Spectrum Communications, Addison Wesley, 1995.
5. VK Garg &JE Wilkes, Wireless & Personal Communication Systems, Prentice Hall, 1996.

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

1. Understand the working principles of the mobile communication systems.
2. Understand the relation between the user features and underlying technology.
3. Analyze mobile communication systems for improved performance

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ECEL10	**Digital Image & Video Processing**	**3L:0T:0P**	**3 credits**

Digital Image Fundamentals-Elements of visual perception, image sensing andacquisition, image sampling and quantization, basic relationships between pixels – neighborhood, adjacency, connectivity, distance measures.

Image Enhancements and Filtering-Gray level transformations, histogramequalization and specifications, pixel-domain smoothing filters – linear and order-statistics, pixel-domain sharpening filters – first and second derivative, two-dimensional DFT and its inverse, frequency domain filters – low-pass and high-pass.

Color Image Processing-Color models–RGB, YUV, HSI; Color transformations– formulation, color complements, color slicing, tone and color corrections; Color image smoothing and sharpening; Color Segmentation.

Image Segmentation- Detection of discontinuities, edge linking and boundarydetection, thresholding – global and adaptive, region-based segmentation.

Wavelets and Multi-resolution image processing- Uncertainty principles of FourierTransform, Time-frequency localization, continuous wavelet transforms, wavelet bases and multi-resolution analysis, wavelets and Subband filter banks, wavelet packets.

Image Compression-Redundancy–inter-pixel and psycho-visual; Losslesscompression – predictive, entropy; Lossy compression- predictive and transform coding; Discrete Cosine Transform; Still image compression standards – JPEG and JPEG-2000.

Fundamentals of Video Coding- Inter-frame redundancy, motion estimationtechniques – full-search, fast search strategies, forward and backward motion prediction, frame classification – I, P and B; Video sequence hierarchy – Group of pictures, frames, slices, macro-blocks and blocks; Elements of a video encoder and decoder; Video coding standards – MPEG and H.26X.

Video Segmentation- Temporal segmentation–shot boundary detection, hard-cutsand soft-cuts; spatial segmentation – motion-based; Video object detection and tracking.

Text/Reference Books:

1. R.C. Gonzalez and R.E. Woods, Digital Image Processing, Second Edition, Pearson Education 3rd edition 2008
2. Anil Kumar Jain, Fundamentals of Digital Image Processing, Prentice Hall of India.2nd edition 2004
3. Murat Tekalp , Digital Video Processing" Prentice Hall, 2nd edition 2015

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

1. Mathematically represent the various types of images and analyze them.
2. Process these images for the enhancement of certain properties or for optimized use of the resources.
3. Develop algorithms for image compression and coding

ECEL11	Mixed Signal Design	3L:0T:0P	3 credits

Analog and discrete-time signal processing, introduction to sampling theory;Analog continuous-time filters: passive and active filters; Basics of analog discrete-time filters and Z-transform.

Switched-capacitor filters- Nonidealities in switched-capacitor filters; Switched-capacitor filter architectures; Switched-capacitor filter applications.

Basics of data converters; Successive approximation ADCs, Dual slope ADCs,Flash ADCs, Pipeline ADCs, Hybrid ADC structures, High-resolution ADCs, DACs.

Mixed-signal layout, Interconnects and data transmission; Voltage-mode signalingand data transmission; Current-mode signaling and data transmission.

Introduction to frequency synthesizers and synchronization; Basics of PLL,Analog PLLs; Digital PLLs; DLLs.

Text/Reference Books:

1. R. Jacob Baker, CMOS mixed-signal circuit design, Wiley India, IEEE press, reprint 2008.
2. Behzad Razavi , Design of analog CMOS integrated circuits, McGraw-Hill, 2003.
3. R. Jacob Baker, CMOS circuit design, layout and simulation, Revised second edition, IEEE press, 2008.
4. Rudy V. dePlassche, CMOS Integrated ADCs and DACs, Springer, Indian edition, 2005.
5. Arthur B. Williams, Electronic Filter Design Handbook, McGraw-Hill, 1981.
6. R. Schauman, Design of analog filters by, Prentice-Hall 1990 (or newer additions).
7. M. Burns et al., An introduction to mixed-signal IC test and measurement by, Oxford university press, first Indian edition, 2008.

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

1. Understand the practical situations where mixed signal analysis is required.
2. Analyze and handle the inter-conversions between signals.
3. Design systems involving mixed signals

ECEL12	Wireless Sensor Networks	3L:0T:0P	3 credits

Introduction to Sensor Networks, unique constraints and challenges, Advantage of Sensor Networks, Applications of Sensor Networks, Types of wireless sensor networks

Mobile Ad-hocNetworks (MANETs) and Wireless Sensor Networks, Enabling technologies for Wireless Sensor Networks. Issues and challenges in wireless sensor networks

Routing protocols, MAC protocols: Classification of MAC Protocols, S-MAC Protocol, B-MAC protocol, IEEE 802.15.4 standard and ZigBee,

Dissemination protocol for large sensor network. Data dissemination, data gathering, and data fusion; Quality of a sensor network; Real-time traffic support and security protocols.

Design Principles for WSNs, Gateway Concepts Need for gateway, WSN to Internet Communication, and Internet to WSN Communication.

Single-node architecture, Hardware components & design constraints,

Operating systems and execution environments, introduction to TinyOS and nesC.

Text/Reference Books:

1. Waltenegus Dargie , Christian Poellabauer, "Fundamentals Of Wireless Sensor Networks Theory And Practice", By John Wiley & Sons Publications ,2011
2. Sabrie Soloman, "Sensors Handbook" by McGraw Hill publication. 2009
3. Feng Zhao, Leonidas Guibas, "Wireless Sensor Networks", Elsevier Publications,2004
4. Kazem Sohrby, Daniel Minoli, "Wireless Sensor Networks": Technology, Protocols and Applications, Wiley-Inter science
5. Philip Levis, And David Gay "TinyOS Programming" by Cambridge University Press 2009

Course Outcomes:

At the end of the course the students will be able to

1. Design wireless sensor networks for a given application
2. Understand emerging research areas in the field of sensor networks
3. Understand MAC protocols used for different communication standards used in WSN
4. Explore new protocols for WSN

ECEL13	**CMOS Design**	**3L:0T:0P**	**3 credits**

Review of MOS transistor models, Non-ideal behavior of the MOS Transistor.Transistor as a switch. Inverter characteristics, Integrated Circuit Layout: Design Rules, Parasitics. Delay: RC Delay model, linear delay model, logical path efforts. Power, interconnect and Robustness in CMOS circuit layout. Combinational Circuit Design: CMOS logic families including static, dynamic and dual rail logic. Sequential Circuit Design: Static circuits. Design of latches and Flip-flops.

Text/Reference Books:

1. N.H.E. Weste and D.M. Harris, CMOS VLSI design: A Circuits and Systems Perspective, 4thEdition, Pearson Education India, 2011.
2. C.Mead and L. Conway, Introduction to VLSI Systems, Addison Wesley, 1979.

3. J. Rabaey, Digital Integrated Circuits: A Design Perspective, Prentice Hall India, 1997.
4. P. Douglas, VHDL: programming by example, McGraw Hill, 2013.
5. L. Glaser and D. Dobberpuhl, The Design and Analysis of VLSI Circuits, Addison Wesley, 1985.

Course Outcomes:

At the end of the course the students will be able to

1. Design different CMOS circuits using various logic families along with their circuit layout.
2. Use tools for VLSI IC design.

ECEL14	**Power Electronics**	**3L:0T:0P**	**3 credits**

Characteristics of Semiconductor Power Devices: Thyristor, power MOSFET and IGBT- Treatment should consist of structure, Characteristics, operation, ratings, protections and thermal considerations. Brief introduction to power devices viz. TRIAC, MOS controlled thyristor (MCT), Power Integrated Circuit (PIC) (Smart Power), Triggering/Driver, commutation and snubber circuits for thyristor, power MOSFETs and IGBTs (discrete and IC based).Concept of fast recovery and schottky diodes as freewheeling and feedback diode.

Controlled Rectifiers: Single phase: Study of semi and full bridge converters for R, RL, RLE and level loads. Analysis of load voltage and input current- Derivations of load form factor and ripple factor, Effect of source impedance, Input current Fourier series analysis of input current to derive input supply power factor, displacement factor and harmonic factor.

Choppers: Quadrant operations of Type A, Type B, Type C, Type D and type E choppers, Control techniques for choppers – TRC and CLC, Detailed analysis of Type A chopper. Step up chopper. Multiphase Chopper

Single-phase inverters: Principle of operation of full bridge square wave, quasi-square wave, PWM inverters and comparison of their performance. Driver circuits for above inverters and mathematical analysis of output (Fourier series) voltage and harmonic control at output of inverter (Fourier analysis of output voltage). Filters at the output of inverters, Single phase current source inverter

Switching Power Supplies: Analysis of fly back, forward converters for SMPS, Resonant converters - need, concept of soft switching, switching trajectory and SOAR, Load resonant converter - series loaded half bridge DC-DC converter.

Applications: Power line disturbances, EMI/EMC, power conditioners. Block diagram and configuration of UPS, salient features of UPS, selection of battery and charger ratings, sizing of UPS. Separately excited DC motor drive. P M Stepper motor Drive.

Text /Reference Books:

1. Muhammad H. Rashid, "Power electronics" Prentice Hall of India.
2. Ned Mohan, Robbins, "Power electronics", edition III, John Wiley and sons.
3. P.C. Sen., "Modern Power Electronics", edition II, Chand& Co.
4. V.R.Moorthi, "Power Electronics", Oxford University Press.
5. Cyril W., Lander," Power Electronics", edition III, McGraw Hill.
6. G K Dubey, S R Doradla,: Thyristorised Power Controllers", New Age International Publishers. SCR manual from GE, USA.

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. Build and test circuits using power devices such as SCR
2. Analyze and design controlled rectifier, DC to DC converters, DC to AC inverters,
3. Learn how to analyze these inverters and some basic applications.
4. Design SMPS.

ECEL15	**Satellite Communication**	**3L:0T:0P**	**3 credits**

Introduction to Satellite Communication: Principles and architecture of satellite Communication, Brief history of Satellite systems, advantages, disadvantages, applications and frequency bands used for satellite communication.

Orbital Mechanics: Orbital equations, Kepler's laws, Apogee and Perigee for an elliptical orbit, evaluation of velocity, orbital period, angular velocity etc. of a satellite, concepts of Solar day and Sidereal day.

Satellite sub-systems: Study of Architecture and Roles of various sub-systems of a satellite system such as Telemetry, tracking, command and monitoring (TTC & M), Attitude and orbit control system (AOCS), Communication sub-system, power sub-systems etc.

Typical Phenomena in Satellite Communication:Solar Eclipse on satellite, its effects, remedies for Eclipse, Sun Transit Outage phenomena, its effects and remedies, Doppler frequency shift phenomena and expression for Doppler shift.
Satellite link budget

Flux density and received signal power equations, Calculation of System noise temperature for satellite receiver, noise power calculation, Drafting of satellite link budget and C/N ratio calculations in clear air and rainy conditions.

Modulation and Multiple Access Schemes:Various modulation schemes used in satellite communication, Meaning of Multiple Access, Multiple access schemes based on time, frequency, and code sharing namely TDMA, FDMA and CDMA.

Text /Reference Books:

1. Timothy Pratt Charles W. Bostian, Jeremy E. Allnutt: Satellite Communications: Wiley India. 2nd edition 2002
2. Tri T. Ha: Digital Satellite Communications: Tata McGraw Hill, 2009
3. Dennis Roddy: Satellite Communication: 4th Edition, McGraw Hill,2009

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. Visualize the architecture of satellite systems as a means of high speed, high range communication system.
2. State various aspects related to satellite systems such as orbital equations, sub-systems in a satellite, link budget, modulation and multiple access schemes.
3. Solve numerical problems related to orbital motion and design of link budget for the given parameters and conditions.

ECEL16	High Speed Electronics	3L:0T:0P	3 credits

Transmission line theory (basics) crosstalk and nonideal effects; signal integrity: impact of packages, vias, traces, connectors; non-ideal return current paths, high frequency powerdelivery, methodologies for design of high speed buses; radiated emissions and minimizing system noise;
Noise Analysis: Sources, Noise Figure, Gain compression, Harmonic distortion, Intermodulation,Cross-modulation, Dynamic range

Devices: Passive and active, Lumped passive devices (models), Active (models,low vs highfrequency)

RF Amplifier Design, Stability, Low Noise Amplifiers, Broadband Amplifiers (and Distributed)
Power Amplifiers, Class A, B, AB and C, D E Integrated circuit realizations, Cross-over distortion Efficiency RF power output stages
Mixers –Upconversion Downconversion, Conversion gain and spurious response.Oscillators Principles.PLL Transceiver architectures
Printed Circuit BoardAnatomy, CAD tools for PCB design, Standard fabrication, Microvia Boards. Board Assembly: Surface Mount Technology, Through Hole Technology, Process Control and Design challenges.

Text/Reference Books:

1. Stephen H. Hall, Garrett W. Hall, James A. McCall “High-Speed Digital System Design: A Handbook of Interconnect Theory and Design Practices”, August 2000, Wiley-IEEE Press
2. Thomas H. Lee, “The Design of CMOS Radio-Frequency Integrated Circuits”, CambridgeUniversity Press, 2004, ISBN 0521835399.
3. Behzad Razavi, “RF Microelectronics”, Prentice-Hall 1998, ISBN 0-13-887571-5.
4. Guillermo Gonzalez, “Microwave Transistor Amplifiers”, 2nd Edition, Prentice Hall.

5. Kai Chang, “RF and Microwave Wireless systems”, Wiley.
6. R.G. Kaduskar and V.B.Baru, Electronic Product design, Wiley India, 2011

Course Outcomes:
At the end of the course, students will demonstrate the ability to:

1. Understand significance and the areas of application of high-speed electronics circuits.
2. Understand the properties of various components used in high speed electronics
3. Design High-speed electronic system using appropriate components.

ECEL17	**Wavelets**	**3L:0T:0P**	**3 credits**

Introduction to time frequency analysis; the how, what and why about wavelets, Short-time Fourier transform, Wigner-Ville transform.;Continuous time wavelet transform, Discrete wavelet transform, tiling of the time-frequency plane and wave packet analysis, Construction of wavelets. Multiresolution analysis. Introduction to frames and biorthogonal wavelets, Multirate signal processing and filter bank theory, Application of wavelet theory to signal denoising, image and video compression, multi-tone digital communication, transient detection.

Text/Reference Books:

1. Y.T. Chan, Wavelet Basics, Kluwer Publishers, Boston, 1993.
2. I. Daubechies, Ten Lectures on Wavelets, Society for Industrial and Applied Mathematics, Philadelphia, PA, 1992.
3. C. K. Chui, An Introduction to Wavelets, Academic Press Inc., New York, 1992.
4. Gerald Kaiser, A Friendly Guide to Wavelets, Birkhauser, New York, 1995.
5. P. P. Vaidyanathan, Multirate Systems and Filter Banks, Prentice Hall, New Jersey, 1993.
6. A.N. Akansu and R.A. Haddad, Multiresolution signal Decomposition: Transforms, Subbands and Wavelets, Academic Press, Oranld, Florida, 1992.
7. B.Boashash, Time-Frequency signal analysis, In S.Haykin, (editor), Advanced Spectral Analysis, pages 418--517. Prentice Hall, New Jersey, 1991.

Course Outcomes:
At the end of the course, students will demonstrate the ability to:

1. Understand time-frequency nature of the signals.
2. Apply the concept of wavelets to practical problems.
3. Mathematically analyze the systems or process the signals using appropriate wavelet functions.

ECEL18	**Embedded Systems**	**3L:0T:0P**	**3 credits**

The concept of embedded systems design, Embedded microcontroller cores, embedded memories. Examples of embedded systems, Technological aspects of embedded systems: interfacing between analog and digital blocks, signal conditioning, digital signal processing. sub-system interfacing, interfacing with external systems, user interfacing. Design tradeoffs due to process compatibility, thermal considerations, etc., Software aspects of embedded systems: real time programming languages and operating systems for embedded systems.

Text/Reference Books:

1. J.W. Valvano, "Embedded Microcomputer System: Real Time Interfacing", Brooks/Cole, 2000.
2. Jack Ganssle, "The Art of Designing Embedded Systems", Newness, 1999.
3. V.K. Madisetti, "VLSI Digital Signal Processing", IEEE Press (NY, USA), 1995.
4. David Simon, "An Embedded Software Primer", Addison Wesley, 2000.
5. K.J. Ayala, "The 8051 Microcontroller: Architecture, Programming, and Applications", Penram Intl, 1996.

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

1. Suggest design approach using advanced controllers to real-life situations.
2. Design interfacing of the systems with other data handling / processing systems.
3. Appreciate engineering constraints like energy dissipation, data exchange speeds etc.

ECEL19	Nano electronics	3L:0T:0P	3 credits

Introduction to nanotechnology, meso structures,Basics of Quantum Mechanics: Schrodinger equation, Density of States. Particle in a box Concepts, Degeneracy. Band Theory of Solids. Kronig-Penny Model. Brillouin Zones.

Shrink-down approaches: Introduction, CMOS Scaling, The nanoscale MOSFET, Finfets, Vertical MOSFETs, limits to scaling, system integration limits (interconnect issues etc.),

Resonant Tunneling Diode, Coulomb dots, Quantum blockade, Single electron transistors,Carbon nanotube electronics, Bandstructure and transport, devices, applications, 2D semiconductors and electronic devices, Graphene, atomistic simulation

Text/ Reference Books:

1. G.W. Hanson, Fundamentals of Nanoelectronics, Pearson, 2009.
2. W. Ranier, Nanoelectronics and Information Technology (Advanced Electronic Materialand Novel Devices), Wiley-VCH, 2003.
3. K.E. Drexler, Nanosystems, Wiley, 1992.
4. J.H. Davies, The Physics of Low-Dimensional Semiconductors, Cambridge University Press, 1998.
5. C.P. Poole, F. J. Owens, Introduction to Nanotechnology, Wiley, 2003

Course Outcomes:
At the end of the course, students will demonstrate the ability to:

1. Understand various aspects of nano-technology and the processes involved in making nano components and material.
2. Leverage advantages of the nano-materials and appropriate use in solving practical problems.
3. Understand various aspects of nano-technology and theprocesses involved in making nano components and material.
4. Leverage advantages of the nano-materials and appropriate use in solving practical problems.

ECEL20	Error Correcting Codes	3L:0T:0P	3 credits

Linear block codes: Systematic linear codes and optimum decoding for the binary symmetric channel; Generator and Parity Check matrices, Syndrome decoding on symmetric channels; Hamming codes; Weight enumerators and the McWilliams identities; Perfect codes, Introduction to finite fields and finite rings;factorization of (X^n-1) over a finite field; Cyclic Codes. BCH codes; Idempotents and Mattson-Solomon polynomials; Reed-Solomon codes, Justeen codes, MDS codes, Alterant, Goppa and generalized BCH codes; Spectral properties of cyclic codes. ;Decoding of BCH codes: Berlekamp's decoding algorithm, Massey's minimum shift register synthesis technique and its relation to Berlekamp's algorithm. A fast Berlekamp - Massey algorithm. Convolution codes; Wozencraft's sequential decoding algorithm, Fann's algorithm and other sequential decoding algorithms; Viterbi decoding algorithm.

Text/Reference Books:

1. F.J. McWilliams and N.J.A. Slone, The theory of error correcting codes, 1977.
2. R.E. Balahut, Theory and practice of error control codes, Addison Wesley, 1983.

Course Outcomes:
At the end of the course, students will demonstrate the ability to:

1. Understand the error sources
2. Understand error control coding applied in digital communication

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ECEL21	Scientific computing	3L:0T:0P	3 credits

Introduction: Sources of Approximations, Data Error and Computational, Truncation Error and Rounding Error, Absolute Error and Relative Error, Sensitivity and Conditioning, Backward Error Analysis, Stability and Accuracy

Computer Arithmetic: Floating Point Numbers, Normalization, Properties of Floating Point System, Rounding, Machine Precision, Subnormal and Gradual Underflow, Exceptional Values, Floating-Point Arithmetic, Cancellation

System of liner equations: Linear Systems, Solving Linear Systems, Gaussian elimination,Pivoting, Gauss-Jordan, Norms and Condition Numbers, Symmetric Positive Definite Systems and Indefinite System, Iterative Methods for Linear Systems

Linear least squares: Data Fitting, Linear Least Squares, Normal Equations Method, Orthogonalization Methods, QR factorization, Gram-Schmidt Orthogonalization, Rank Deficiency, and Column Pivoting

Eigenvalues and singular values:Eigenvalues and Eigenvectors, Methods for Computing All Eigenvalues, Jacobi Method, Methods for Computing Selected Eigenvalues, Singular Values Decomposition, Application of SVD

Nonlinear equations: Fixed Point Iteration, Newton's Method, Inverse Interpolation Method
Optimization: One-Dimensional Optimization, Multidimensional Unconstrained Optimization, Nonlinear Least Squares

Interpolation:Purpose for Interpolation, Choice of Interpolating, Function, Polynomial Interpolation, Piecewise Polynomial Interpolation

Numerical Integration And Differentiation: Quadrature Rule, Newton-Cotes Rule, Gaussian Quadrature Rule, Finite Difference Approximation,

Initial Value Problems for ODES, Euler's Method, Taylor Series Method, Runga-Kutta Method, Extrapolation Methods, Boundary Value Problems For ODES, Finite Difference Methods, Finite Element Method, Eigenvalue Problems

Partial Differential Equations,Time Dependent Problems, Time Independent Problems, Solution for Sparse Linear Systems, Iterative Methods

Fast Fourier Transform, FFT Algorithm, Limitations, DFT, Fast polynomial Multiplication, Wavelets,Random Numbers And Simulation, Stochastic Simulation, Random Number Generators, Quasi-Random Sequences

Text/ Reference Books:

1. Heath Michael T., "Scientific Computing: An Introductory Survey", McGraw-Hill, 2nd Ed., 2002
2. Press William H., Saul A. Teukolsky, Vetterling William T and Brian P. Flannery, "Numerical Recipes: The Art of Scientific Computing", Cambridge University Press, 3rd Ed., 2007

3. Xin-she Yang (Ed.)., "Introduction To Computational Mathematics", World Scientific Publishing Co., 2nd Ed., 2008
4. Kiryanov D. and Kiryanova E., "Computational Science", Infinity Science Press, 1st Ed., 2006
5. Quarteroni, Alfio, Saleri, Fausto, Gervasio and Paola, "Scientific Computing With MATLAB And Octave", Springer, 3rd Ed., 2010

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

1. Understand the significance of computing methods, their strengths and application areas.
2. Perform the computations on various data using appropriate computation tools.

PROJECT

ECP1	Project Work –I

The object of Project Work I is to enable the student to take up investigative study in the broad field of Electronics & Communication Engineering, either fully theoretical/practical or involving both theoretical and practical work to be assigned by the Department on an individual basis or two/three students in a group, under the guidance of a Supervisor. This is expected to provide a good initiation for the student(s) in R&D work. The assignment to normally include:

1. Survey and study of published literature on the assigned topic;
2. Working out a preliminary Approach to the Problem relating to the assigned topic;
3. Conducting preliminary Analysis/Modelling/Simulation/Experiment/Design/Feasibility;
4. Preparing a Written Report on the Study conducted for presentation to the Department;
5. Final Seminar, as oral Presentation before a departmental committee.

ECP2	Project Work II & Dissertation

The object of Project Work II & Dissertation is to enable the student to extend further the investigative study taken up under EC P1, either fully theoretical/practical or involving both theoretical and practical work, under the guidance of a Supervisor from the Department alone or jointly with a Supervisor drawn from R&D laboratory/Industry. This is expected to provide a good training for the student(s) in R&D work and technical leadership. The assignment to normally include:

1. In depth study of the topic assigned in the light of the Report prepared under EC P1;
2. Review and finalization of the Approach to the Problem relating to the assigned topic;
3. Preparing an Action Plan for conducting the investigation, including team work;
4. Detailed Analysis/Modelling/Simulation/Design/Problem Solving/Experiment as needed;
5. Final development of product/process, testing, results, conclusions and future directions;
6. Preparing a paper for Conference presentation/Publication in Journals, if possible;
7. Preparing a Dissertation in the standard format for being evaluated by the Department.
8. Final Seminar Presentation before a Departmental Committee.

MODEL CURRICULUM

for

COMMON COURSES
IN

PHYSICS, CHEMISTRY, BIOLOGY
&
MATHEMATICS

(Engineering & Technology)

[January 2018]

ALL INDIA COUNCIL FOR TECHNICAL EDUCATION
Nelson Mandela Marg, Vasant Kunj, New Delhi 110 070
www.aicte-india.org

All India Council for Technical Education
Model curriculum for
Undergraduate Degree Courses in Engineering & Technology

COMMON COURSES
PHYSICS, CHEMISTRY, BIOLOGY & MATHEMATICS

CONTENTS

Sl. No.	Chapter	sTitle
1	**Physics**	**Physics** (i) Introduction to Electromagnetic Theory (ii) Introduction to Mechanics (iii) Quantum Mechanics for Engineers (iv) Oscillation, Waves and Optics (v) Semiconductor Optoelectronics (vi) Semiconductor Physics
2	**Chemistry & Biology**	**Chemistry** (i) Chemistry – I(Concepts in chemistry for engineering) (ii) Chemistry Laboratory **Elective Courses** (i) Chemistry-II (Chemical Applications) (ii) Polymer Chemistry (iii) Experiments in Polymer Chemistry **Biology**
3	**Mathematics**	**(i)Mathematics(Option 1)** Mathematics 1 Mathematics 2 Mathematics 3 **(ii)Mathematics (Option 2) (for CSE students)** **(iii)Mathematics Modules**

All Indian Council for Technical Education
Physics
Introduction to Electromagnetic

Theory Prerequisite: Mathematics course with vector calculus

Module 1: Electrostatics in vacuum **(8)**
Calculation of electric field and electrostatic potential for a charge distribution; Divergence and curl of electrostatic field; Laplace's and Poisson's equations for electrostatic potential and uniqueness of their solution and connection with steady state diffusion and thermal conduction; Practical examples like Farady's cage and coffee-ring effect; Boundary conditions of electric field and electrostatic potential; method of images; energy of a charge distribution and its expression in terms of electric field.

Module 2: Electrostatics in a linear dielectric medium **(4)**
Electrostatic field and potential of a dipole. Bound charges due to electric polarization; Electric displacement; boundary conditions on displacement; Solving simple electrostatics problems in presence of dielectrics – Point charge at the centre of a dielectric sphere, charge in front of a dielectric slab, dielectric slab and dielectric sphere in uniform electric field.

Module 3: Magnetostatics **(6)**
Bio-Savart law, Divergence and curl of static magnetic field; vector potential and calculating it for a given magnetic field using Stokes' theorem; the equation for the vector potential and its solution for given current densities.

Module 4: Magnetostatics in a linear magnetic medium **(3)**
Magnetization and associated bound currents; auxiliary magnetic field $\vec{H}$; Boundary conditions on $\vec{B}$ and $\vec{H}$. Solving for magnetic field due to simple magnets like a bar magnet; magnetic susceptibility and feromagnetic, paramagnetic and diamagnetic materials; Qualitative discussion of magnetic field in presence of magnetic materials.

Module 5: Faraday's law **(4)**
Faraday's law in terms of EMF produced by changing magnetic flux; equivalence of Faraday's law and motional EMF; Lenz's law; Electromagnetic breaking and its applications; Differential form of Faraday's law expressing curl of electric field in terms of time-derivative of magnetic field and calculating electric field due to changing magnetic fields in quasi-static approximation; energy stored in a magnetic field.

Module 6: Displacement current, Magnetic field due to time-dependent electric field and Maxwell's equations **(5)**

Continuity equation for current densities; Modifying equation for the curl of magnetic field to satisfy continuity equation; displace current and magnetic field arising from time-dependent electric field; calculating magnetic field due to changing electric fields in quasi-static approximation.

Maxwell's equation in vacuum and non-conducting medium; Energy in an electromagnetic field; Flow of energy and Poynting vector with examples. Qualitative discussion of momentum in electromagnetic fields.

Module 7: Electromagnetic waves **(8)**

The wave equation; Plane electromagnetic waves in vacuum, their transverse nature and polarization; relation between electric and magnetic fields of an electromagnetic wave; energy carried by electromagnetic waves and examples. Momentum carried by electromagnetic waves and resultant pressure. Reflection and transmission of electromagnetic waves from a non-conducting medium-vacuum interface for normal incidence.

Text Book:

(i) David Griffiths, Introduction to Electrodynamics

Reference books:

(i) Halliday and Resnick, Physics
(ii) W. Saslow, Electricity, magnetism and light

All India Council for Technical Education
Physics :
Mechanics

Prerequisites: (i) High-school education

Module 1: (**8**)
Transformation of scalars and vectors under Rotation transformation; Forces in Nature; Newton's laws and its completeness in describing particle motion; Form invariance of Newton's Second Law; Solving Newton's equations of motion in polar coordinates; Problems including constraints and friction; Extension to cylindrical and spherical coordinates

Module 2: (**7**)
Potential energy function; F = - Grad V, equipotential surfaces and meaning of gradient; Conservative and non-conservative forces, curl of a force field; Central forces; Conservation of Angular Momentum; Energy equation and energy diagrams; Elliptical, parabolic and hyperbolic orbits; Kepler problem; Application: Satellite manoeuvres;

Module 3: (**5**)
Non-inertial frames of reference; Rotating coordinate system: Five-term acceleration formula-Centripetal and Coriolis accelerations; Applications: Weather systems, Foucault pendulum;

Module 4: (**6**)
Harmonic oscillator; Damped harmonic motion – over-damped, critically damped and lightly-damped oscillators; Forced oscillations and resonance

Module 5: (5)
Definition and motion of a rigid body in the plane; Rotation in the plane; Kinematics in a coordinate system rotating and translating in the plane; Angular momentum about a point of a rigid body in planar motion; Euler's laws of motion, their independence from Newton's laws, and their necessity in describing rigid body motion; Examples

Module 6: (7)
Introduction to three-dimensional rigid body motion — only need to highlight the distinction from two-dimensional motion in terms of (a) Angular velocity vector, and its rate of change and (b) Moment of inertia tensor; Three-dimensional motion of a rigid body wherein all points move in a coplanar manner: e.g. Rod executing conical motion with center of mass fixed — only need to show that this motion looks two-dimensional but is three-dimensional, and two-dimensional formulation fails.

Reference books:

(i) Engineering Mechanics, 2nd ed. — MK Harbola
(ii) Introduction to Mechanics — MK Verma
(iii) An Introduction to Mechanics — D Kleppner & R Kolenkow
(iv) Principles of Mechanics — JL Synge & BA Griffiths
(v) Mechanics — JP Den Hartog
(vi) Engineering Mechanics - Dynamics, 7th ed. - JL Meriam
(vii) Mechanical Vibrations — JP Den Hartog
(viii) Theory of Vibrations with Applications — WT Thomson

All India Council for Technical Education
Introduction to Quantum Mechanics for Engineers

Prerequisite: Mathematics course on differential equations and linear algebra

Module 1: Wave nature of particles and the Schrodinger equation **(8)**
Introduction to Quantum mechanics, Wave nature of Particles, Time-dependent and time-independent Schrodinger equation for wavefunction, Born interpretation, probability current, Expectation values, Free-particle wavefunction and wave-packets, Uncertainty principle

Module 2: Mathematical Preliminaries for quantum mechanics **(4)**
Complex numbers, Linear vector spaces, inner product, operators, eigenvalue problems, Hermitian operators, Hermite polynomials, Legendre's equation, spherical harmonics.

Module 3: Applying the Schrodinger equation **(15)**
Solution of stationary-state Schrodinger equation for one dimensional problems– particle in a box, particle in attractive delta-function potential, square-well potential, linear harmonic oscillator.
Numerical solution of stationary-state Schrodinger equation for one dimensional problems for different potentials
Scattering from a potential barrier and tunneling; related examples like alpha-decay, field-ionization and scanning tunneling microscope
Three-dimensional problems: particle in three dimensional box and related examples, Angular momentum operator, Rigid Rotor, Hydrogen atom ground-state, orbitals, interaction with magnetic field, spin
Numerical solution stationary-state radial Schrodinger equation for spherically symmetric potentials

Module 4: Introduction to molecular bonding **(4)**
Particle in double delta-function potential, Molecules (hydrogen molecule, valence bond and molecular orbitals picture), singlet/triplet states, chemical bonding, hybridization

Module 5: Introduction to solids **(7)**
Free electron theory of metals, Fermi level, density of states, Application to white dwarfs and neutron stars, Bloch's theorem for particles in a periodic potential, Kronig-Penney model and origin of energy bands
Numerical solution for energy in one-dimensional periodic lattice by mixing plane waves.

Text book: Eisberg and Resnick, Introduction to Quantum Physics

Reference Books: D. J. Griffiths, Quantum mechanics Richard Robinett, Quantum Mechanics Daniel McQuarrie, Quantum Chemistry

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All India Council for Technical Education
Physics
Oscillations, waves and optics

Prerequisites:

(i) Mathematics course on Differential equations

(ii) Introduction to Electromagnetic theory

Module 1: Simple harmonic motion, damped and forced simple harmonic oscillator **(7)**

Mechanical and electrical simple harmonic oscillators, complex number notation and phasor representation of simple harmonic motion, damped harmonic oscillator – heavy, critical and light damping, energy decay in a damped harmonic oscillator, quality factor, forced mechanical and electrical oscillators, electrical and mechanical impedance, steady state motion of forced damped harmonic oscillator, power absorbed by oscillator

Module 2: Non-dispersive transverse and longitudinal waves in one dimension and introduction to dispersion **(7)**

Transverse wave on a string, the wave equation on a string, Harmonic waves, reflection and transmission of waves at a boundary, impedance matching, standing waves and their eigenfrequencies, longitudinal waves and the wave equation for them, acoustics waves and speed of sound, standing sound waves.

Waves with dispersion, water waves, superposition of waves and Fourier method, wave groups and group velocity.

Module 3: The propagation of light and geometric optics **(10)**

Fermat’s principle of stationary time and its applications e.g. in explaining mirage effect, laws of reflection and refraction, Light as an electromagnetic wave and Fresnel equations, reflectance and transmittance, Brewster’s angle, total internal reflection, and evanescent wave.

Mirrors and lenses and optical instruments based on them, transfer formula and the matrix method

Module 4: Wave optics **(6)**

Huygens’ principle, superposition of waves and interference of light by wavefront splitting and amplitude splitting; Young’s double slit experiment, Newton’s rings, Michelson interferometer, Mach-Zehnder interferometer.

Farunhofer diffraction from a single slit and a circular aperture, the Rayleigh criterion for limit of resolution and its application to vision; Diffraction gratings and their resolving power

Module 5: Lasers **(8)**

Einstein’s theory of matter radiation interaction and A and B coefficients; amplification of light by population inversion, different types of lasers: gas lasers (He-Ne, CO_2), solid-state lasers(ruby, Neodymium), dye lasers; Properties of laser beams: mono-chromaticity, coherence, directionality and brightness, laser speckles, applications of lasers in science, engineering and medicine.

Reference books:

(i) Ian G. Main, Oscillations and waves in physics
(ii) H.J. Pain, The physics of vibrations and waves
(iii) E. Hecht, Optics
(iv) A. Ghatak, Optics
(v) O. Svelto, Principles of Lasers

All India Council for Technical Courses
Physics
Semiconductor Optoelectronics

Prerequisite: Semiconductor physics

Module 1: Review of semiconductor physics **(10)**
E-k diagram, Density of states, Occupation probability, Fermi level and quasi-Fermi level (variation by carrier concentration and temperature); p-n junction, Metal-semiconductor junction (Ohmic and Schottky); Carrier transport, generation, and recombination; Semiconductor materials of interest for optoelectronic devices, bandgap modification, heterostructures; Light-semiconductor interaction: Rates of optical transitions, joint density of states, condition for optical amplification.

Module 2: Semiconductor light emitting diodes (LEDs) **(6)**
Rate equations for carrier density, Radiative and non-radiative recombination mechanisms in semiconductors, LED: device structure, materials, characteristics, and figures of merit.

Module 3: Semiconductor lasers **(8)**
Review of laser physics; Rate equations for carrier- and photon-density, and their steady state solutions, Laser dynamics, Relaxation oscillations, Input-output characteristics of lasers. Semiconductor laser: structure, materials, device characteristics, and figures of merit; DFB, DBR, and vertical-cavity surface-emitting lasers (VECSEL), Tunable semiconductor lasers.

Module 4: Photodetectors **(6)**
Types of semiconductor photodetectors -p-n junction, PIN, and Avalanche --- and their structure, materials, working principle, and characteristics, Noise limits on performance; Solar cells.

Module 5: Low-dimensional optoelectronic devices **(6)** Quantum-well, -wire, and -dot based LEDs, lasers, and photodetectors.

References:

1. J. Singh, Semiconductor Optoelectronics: Physics and Technology, McGraw-Hill Inc. (1995).
2. B. E. A. Saleh and M. C. Teich, Fundamentals of Photonics, John Wiley & Sons,
3. S. M. Sze, Semiconductor Devices: Physics and Technology, Wiley (2008).

4. A. Yariv and P. Yeh, Photonics: Optical Electronics in Modern Communications, Oxford University Press, New York (2007).

5. P. Bhattacharya, Semiconductor Optoelectronic Devices, Prentice Hall of India (1997).
6. Online course: “Semiconductor Optoelectronics” by M R Shenoy on NPTEL

7. Online course: "Optoelectronic Materials and Devices" by Monica Katiyar and Deepak Gupta on NPTEL

All India Council for Technical Education
Physics
Semiconductor Physics

Prerequisite: " Introduction to Quantum Mechanics" Desirable

Module 1: Electronic materials **(8)**
Free electron theory, Density of states and energy band diagrams, Kronig-Penny model (to introduce origin of band gap), Energy bands in solids, E-k diagram, Direct and indirect bandgaps, Types of electronic materials: metals, semiconductors, and insulators, Density of states, Occupation probability, Fermi level, Effective mass, Phonons.

Module 2: Semiconductors **(10)**
Intrinsic and extrinsic semiconductors, Dependence of Fermi level on carrier-concentration and temperature (equilibrium carrier statistics), Carrier generation and recombination, Carrier transport: diffusion and drift, p-n junction, Metal-semiconductor junction (Ohmic and Schottky), Semiconductor materials of interest for optoelectronic devices.

Module 3: Light-semiconductor interaction **(6)**
Optical transitions in bulk semiconductors: absorption, spontaneous emission, and stimulated emission; Joint density of states, Density of states for photons, Transition rates (Fermi's golden rule), Optical loss and gain; Photovoltaic effect, Exciton, Drude model.

Module 4: Measurements **(6)**
Four-point probe and van der Pauw measurements for carrier density, resistivity, and hall mobility; Hot-point probe measurement, capacitance-voltage measurements, parameter extraction from diode I-V characteristics, DLTS, band gap by UV-Vis spectroscopy, absorption/transmission.

Module 5: Engineered semiconductor materials **(6)**
Density of states in 2D, 1d and 0D (qualitatively). Practical examples of low-dimensional systems such as quantum wells, wires, and dots: design, fabrication, and characterization techniques. Heterojunctions and associated band-diagrams

References:

1. J. Singh, Semiconductor Optoelectronics: Physics and Technology, McGraw-Hill Inc. (1995).
2. B. E. A. Saleh and M. C. Teich, Fundamentals of Photonics, John Wiley & Sons, Inc., (2007).
3. S. M. Sze, Semiconductor Devices: Physics and Technology, Wiley (2008).
4. A. Yariv and P. Yeh, Photonics: Optical Electronics in Modern Communications, Oxford University Press, New York (2007).
5. P. Bhattacharya, Semiconductor Optoelectronic Devices, Prentice Hall of India (1997).
6. Online course: "Semiconductor Optoelectronics" by M R Shenoy on NPTEL
7. Online course: "Optoelectronic Materials and Devices" by Monica Katiyar and Deepak Gupta on NPTEL

All India Council for Technical Education

Model Chemistry/Biology Course Contents

In view of the inclusion of 5.5 credits for chemistry and 3 credits for biology for the B.E/B. Tech/equivalent students, the chemistry and biology courses are organized as follows.

Compulsory courses

1) Chemistry-I (Concepts in chemistry for engineering) – (4 credits)
2) Chemistry Laboratory – (1.5 credits)
3) Biology-I (3 Credits)

Elective courses

1) Chemistry-II (Chemical Applications) – 4 credits/3 credits
2) Polymer Chemistry (3 credits)
3) Experiments in Polymer Chemistry (2 Credits)

The course Chemistry – II (Chemical Applications) which is an elective course,will explore applications of chemistry that includes polymers, surfactants, nanomaterials, environmental and green chemistry, biomolecules and analytical techniques.

Courses in Polymer Chemistry and Experiments in Polymer Chemistry are electives.

The course Biology-I is a compulsory course that conveys that Biology is as important a scientific discipline as Mathematics, Physics and Chemistry. It also conveys that 1) "Genetics is to biology what Newton's laws are to Physical Sciences", 2) all forms of life have the same building blocks and yet the manifestations are as diverse as one can imagine, 3) without catalysis life would not have existed on earth, 4) molecular basis of coding and decoding (genetic information) is universal and that 5) fundamental principles of chemical and physical energy transactions are the same in physical/chemical and biological world.

Course contents

Basic Science Course	**Chemistry – I(**Concepts in chemistry for engineering)	**3L:1T:0P**	**4 Credits**

(i) Atomic and molecular structure (12 lectures)

Schrodinger equation. Particle in a box solutions and their applications for conjugated molecules and nanoparticles. Forms of the hydrogen atom wave functions and the plots of these functions to explore their spatial variations. Molecular orbitals of diatomic molecules and plots of the multicentre orbitals. Equations for atomic and molecular orbitals. Energy level diagrams of diatomics. Pi-molecular orbitals of butadiene and benzene and aromaticity. Crystal field theory and the energy level diagrams for transition metal ions and their magnetic properties. Band structure of solids and the role of doping on band structures.

(ii) Spectroscopic techniques and applications (8 lectures)

Principles of spectroscopy and selection rules. Electronic spectroscopy. Fluorescence and its applications in medicine. Vibrational and rotational spectroscopy of diatomic molecules. Applications. Nuclear magnetic resonance and magnetic resonance imaging, surface characterisation techniques. Diffraction and scattering.

(iii) Intermolecular forces and potential energy surfaces (4 lectures)
Ionic, dipolar and van Der Waals interactions. Equations of state of real gases and critical phenomena. Potential energy surfaces of H_3, H_2F and HCN and trajectories on these surfaces.

(iv) Use of free energy in chemical equilibria (6 lectures)
Thermodynamic functions: energy, entropy and free energy. Estimations of entropy and free energies. Free energy and emf. Cell potentials, the Nernst equation and applications. Acid base, oxidation reduction and solubility equilibria. Waterchemistry. Corrosion. Use of free energy considerations in metallurgy through Ellingham diagrams.

(v) Periodic properties (4 Lectures)
Effective nuclear charge, penetration of orbitals, variations of s, p, d and f orbital energies of atoms in the periodic table, electronic configurations, atomic and ionic sizes, ionization energies, electron affinity and electronegativity, polarizability, oxidation states, coordination numbers and geometries, hard soft acids and bases, molecular geometries

(vi) Stereochemistry (4 lectures)
Representations of 3 dimensional structures, structural isomers and stereoisomers, configurations and symmetry and chirality, enantiomers, diastereomers, optical activity, absolute configurations and conformational analysis. Isomerism in transitional metal compounds

(vii) Organic reactions and synthesis of a drug molecule (4 lectures)
Introduction to reactions involving substitution, addition, elimination, oxidation, reduction, cyclization and ring openings. Synthesis of a commonly used drug molecule.

Books:

1) University chemistry, by B. H. Mahan
2) Chemistry: Principles and Applications, byM. J. Sienko andR. A. Plane
3) Fundamentals of Molecular Spectroscopy, by C. N. Banwell
4) Engineering Chemistry (NPTEL Web-book), by B. L. Tembe, Kamaluddin and M. S. Krishnan
5) Physical Chemistry, by P. W. Atkins
6) Organic Chemistry: Structure and Function by K. P. C. Volhardt and N. E. Schore, 5th Edition http://bcs.whfreeman.com/vollhardtschore5e/default.asp

Course Outcomes

The concepts developed in this course will aid in quantification of several concepts in chemistry that have been introduced at the 10+2 levels in schools. Technology is being increasingly based on the electronic, atomic and molecular level modifications.

Quantum theory is more than 100 years old and to understand phenomena at nanometer levels, one has to base the description of all chemical processes at molecular levels. The course will enable the student to:

Analyse microscopic chemistry in terms of atomic and molecular orbitals and intermolecular forces.

Rationalise bulk properties and processes using thermodynamic considerations.

Distinguish the ranges of the electromagnetic spectrum used for exciting different molecular energy levels in various spectroscopic techniques

Rationalise periodic properties such as ionization potential, electronegativity, oxidation states and electronegativity.

List major chemical reactions that are used in the synthesis of molecules.

Chemistry Laboratory (1.5 credits)

- Choice of 10-12 experiments from the following
- Determination of surface tension and viscosity
- Thin layer chromatography
- Ion exchange column for removal of hardness of water
- Determination of chloride content of water
- Colligative properties using freezing point depression
- Determination of the rate constant of a reaction
- Determination of cell constant and conductance of solutions
- Potentiometry - determination of redox potentials and emfs
- Synthesis of a polymer/drug
- Saponification/acid value of an oil
- Chemical analysis of a salt
- Lattice structures and packing of spheres
- Models of potential energy surfaces
- Chemical oscillations- Iodine clock reaction
- Determination of the partition coefficient of a substance between two immiscible liquids
- Adsorption of acetic acid by charcoal
- Use of the capillary viscosimeters to the demonstrate of the isoelectric point as the pH of minimum viscosity for gelatin sols and/or coagulation of the white part of egg

Course Outcomes

The chemistry laboratory course will consist of experiments illustrating the principles of chemistry relevant to the study of science and engineering. The students will learn to:

- Estimate rate constants of reactions from concentration of reactants/products as a function of time
- Measure molecular/system properties such as surface tension, viscosity, conductance of solutions, redox potentials, chloride content of water, etc
- Synthesize a small drug molecule and analyse a salt sample

Elective Courses

Chemistry – II,(Elective)Chemical Applications (4/3 credits)

(i) Polymers (8)

Mechanism of polymerization and synthesis of polymers. Molecular weight, shape and conformation of polymers. Crystallinity, melting point and glass transition. Copolymerization. Viscoelasticity. Elastomers-structure, applications and curing. Conducting polymers and applications. Dendrimers. Solubility of polymers. Fabrication and moulding of polymers. Synthesis, properties and uses of PE, PVC, PMMA, formaldehyde resins, melamine-formaldehyde-urea resins. Adhesives, adhesive mechanism and applications. Composites: characteristics, types and applications. Nanocomposites. Metallic and non-metallic fillers.

(ii) Surfactants and Lubricants (4)

Methods of preparation, cleaning mechanism. Critical micelle concentration and its determination. Hydrophobic and hydrophilic interactions. Micelles and reverse micelles. Detergents. Fricohesity of surfactants. Lubricants-physical and chemical properties, types and mechanism of lubrication. Additives of lubricants and freezing points of lubricants.

(iii) Corrosion (4*)*

Thermodynamic overview of electrochemical processes. Reversible and irreversible cells. Chemical and electrochemical corrosion and mechanism of corrosion. Factors affecting corrosion. Protection of corrosion and practical problems of corrosion.

(iv) New Materials/Nanomaterials (6)

Nanomaterials. Properties and application of fullerenes, fullerols, carbon nanotubes and nanowires. Synthesis-top down and bottom up approaches. Nanoelectronics. Applications of nanomaterials in catalysis, telecommunication and medicine.

(v) Environmental and green chemistry (6)

Air, water and noise pollution. Optimum levels of pollution. Significance and determination of COD and BOD. Solid waste treatment of collection of NKP. Greenhouse effect and global warming. e-Waste. radioactive pollution. Applications of green chemistry and green technology. Concept of atomic and molecular economy and its use in green chemistry.

(vi) Energy science (6)
Analysis of coal. Petroleum refining, liquid fuels, anti-knock agents. Cracking of oils. Limitations of fossil fuels. Alternative and non-conventional sources of energy – solar, wind, geo, hydro-power and biomass. Advantages and disadvantages. Nuclear energy, reactors and nuclear waste disposal. Safety measures for nuclear reactors. Battery technology. Rechargeable batteries. Fuel cells. Photovoltaics.

(vii) Metals and Alloys (4)
Phase rule and applications to one, two and multi-component systems. Iron-carbon phase diagram. Types of alloys, carbon steel, alloy steel, alloys of Cu, AL, Pb.

(viii) Modern Analytical techniques (4)
Mass spectrometry. Thermal analysis. Electron microscopy, scanning tunnelling microscope and atomic force microscope. Sensors. Lab-on-a-chip

Books

(1) Introduction to Nanoscience, by S. M. Lindsay
(2) A Textbook of Engineering Chemistry, by Shashi Chawla
(3) Engineering Chemistry, by S. S. Dara
(4) Engineering Chemistry, by P. C Jain and M. Jain
(5) Journal of Biochem. Biophys. Methods, Vol 67 (2006) pp 151-161
(6) International Journal of Environmental and Analytical Chemistry, Vol 91 (2011), pp 272-279
(7) Advanced Polymer Chemistry, by M. Chanda
(8) A Textbook of Environmental Chemistry, by O. D. Tyagi and M. Mehra
(9) Energy Scenario beyond 2100, by S. Muthukrishna Iyer
10) Physical Chemistry of Metals, by L. S. Darken and R. W. Gurry
11) Surfactants and Polymers in Aqueous Solution, by K. Holmberg, B. Jonsson, B. Kronberg and B. Lindman
12) Physical Metallurgy, by R. E. Reed-Hill

Course Outcomes
This course applies the principles studied in Chemistry – I to understand the structures of different types of molecules in various environments. The students will be able distinguish between the structures, reactions and synthesis of polymers, surfactants, lubricants, metals, alloys, colloids and nanomaterials. New analytical techniques will be compared with the classical methods that use gravimetric and volumetric analysis. Chemical analysis of corrosion will be made. Green chemistry, environmental chemistry and non-conventional energy sources will be assessed in the present context.

Elective

Polymer Chemistry, (3 Credits; 2 lectures and 1 tutorial per week)

This course is an introduction to polymer science that explores synthesis, physical properties and kinetics of polymers/macromolecules. It also explores their conformations and transitions using equilibrium thermodynamics and kinetics.

PREREQUISITES: Chemistry I and Chemistry II of AICTE syllabus

Module 1. Definitions, origin, nomenclature, classification and types of macromolecules; molecular weight (MW) and its distribution; Determination of molecular weight - methods for measuring number average, weight average, viscosity average MW; gel permeation chromatography; spectroscopic techniques to determine chemical composition and molecular microstructure, thermal transitions; melting temperature and glass transition temperature. Colligative properties, osmotic pressure, light scattering, refractive index, viscosity, small angle X-ray scattering (6)

Module 2. Step-Growth Polymerization: Reactivity of functional groups; kinetics; molecular weight in open and closed system cyclization vs. linear polymerization, cross-linking and gel point; process condition; step-copolymerization, examples of step polymers (3)

Module 3. Free radical Polymerization: Nature of chain polymerization and its comparison with step polymerization; radical vs. ionic polymerizations; structural arrangements of monomer units; kinetics of chain polymerization; molecular weight and its distribution; chain transfer, inhibition, retardation, auto-acceleration; energetic characteristics; techniques of radical polymerization – bulk, solution, emulsion, suspension polymerization; examples of polymers made by radical chain polymerization (4)

Module 4. Ionic Polymerization: Propagation and termination of cationic polymerization, anionic and ring opening polymerization, active polycarbanions (2)

Module 5. Copolymerization: types of copolymers, copolymer compositions, reactivity ratio; radical and ionic copolymerizations; Block and Graft copolymer synthesis, examples (2).

Module 6. Thermodynamics of polymer solutions; Flory-Huggins theory, theta conditions; solubility parameters; fractionation of macromolecules, osmotic pressure, lower critical solution temperature (3)

Module 7. Naturally occurring polymers, biodegradability, biosynthesis, polymers from bio/renewable resources (2)

Module 8. Polymers for Electronics: Polymer resists for integrated circuit fabrication, lithography and photolithography, Electron beam, X-ray and ion sensitive resists,Conducting polymers, types, properties and applications, electroluminescence, molecular basis of electrical conductivity, Photonic applications and non-linear optics, optical information storage (3)

Module 9. Fibres: Polyesters, mechanical requirements for fibers, drawing, orientation and crystallinity, stress strain curves; Carbon fibres and nanotubes, Polymer blends and composites: characteristics, types and applications; Polymer films in sensor applications (3)
Books:

1) NPTEL Polymer Chemistry Course, D. Dhara, IIT Kharagpur
2) Polymer chemistry and Physics of Modern Materials, 2nd edn, J. M. G. Cowie, Stanley Thornes, UK, 1998
3) Contemporary Polymer Chemistry, 3rd edn. H. R. Allcock, F. W. Lampe and J. E. Mark, Pearson
4) Polymers: Chemistry and Physics of Modern Materials, J.M.G. Cowie, CRC Press
5) Introduction to Physical Polymer Science, L. H. Sperling, Wiley
6) Introduction to Soft matter, I. W. Hamley, John Wiley and Sons, 2007
7) Polymer Chemistry, 2nd edn, P. C. Hiemenz and T. P. Lodge, CRC Press (2007)

8) Principles of Polymer Chemistry, P. J. Flory, Cornell University Press, 1953

Course Outcomes

After studying this course, the learners are expected to:

Relate polymer properties to their structure and conformation

Analyse different mechanisms of polymer formation and use this information in the synthesis of different polymers

Distinguish between enthalpic and entropic contributions to polymerisation/crystallization.

Distinguish between absolute and relative methods for molecular weight determination.

Determine the flow properties of polymer melts and solutions.

Interpret experimental data and determine parameters such as polymerization rates and copolymer composition.

Estimate the solubility of a given polymer in various solvents and blends.

Evaluate the effect of factors such as polymer structure, molecular weight, branching and diluents on crystallinity.

Assess the effect of synthetic polymers on the environment.

Experiments in Polymer Chemistry, Elective (2 Credits; One 4 hour lab per week)

(Since there could be toxic vapours in these experiments, all experiments should be carried out in hoods that can be covered and the students should always wear safety glasses, lab-coats and shoes. Some of these experiments will help in developing good synthetic skills)

1) Measurements of Molecular weights and molecular weight determination of polymers
2) Determination of viscosity of dilute polymeric solutions
3) Measurement of osmotic pressure of polymeric solutions
4) Measurement of elastic constants of elastomers
5) Preparation of nylon films by condensation polymerization
6) Free radical polymerization and characterization of polymethylmethacrylate (PMMA)
7) Free radical block polymerization of styrene
8) Preparation of polystyrene by anionic/cationic/emulsion polymerization method
9) Condensation polymerization of an unsated polyester
10) Preparation of Poly(1,4-butylene isophthalate)
11) Synthesis of a Fluorescent Conjugated polymer, poly[2-methoxy-5-(2ethylhexyloxy)-1,4-phenylenevinylene] (MEH-PPV)
12) Preparation of epoxy resins
13) Experiments on degradation of polymers
14) Structural analysis of polymers by Fourier Transform Infrared (FTIR) Spectroscopy
15) Demonstration of techniques such as gel permeation chromatography, light scattering, optical microscopy, X-ray diffraction, nuclear magnetic resonance and thermogravimetric analysis and differential scanning calorimetry

References:

1) Polymer synthesis and characterization: A laboratory Manual, S. R. Sandler, W. Caro, J. Bonesteel and E. M. Pearce, Academic Press (1998)
2) Laboratory Procedures in Polymer Chemistry, P. Jannasch, Lund University, http://www.polymat.lth.se/courses/pol_chem/PKEMI_LaboratoryProcedures.pdf
3) C. Duval-Terrie and L. Leburn, J. Chemical Education, 443, **83** (2006)
4) T. Mako and M. Levine, J. Chemical Education, 1376, **90** (2013)

Course Outcomes

The course will help the students to gain hands-on experience in making different polymers, distinguish between different polymer structures, classify polymers and analyse the mechanisms of polymerisation. The uses of polymers in different walks of life will also be appreciated.

BIOLOGY

Basic Science Course	**Biology**	**2L:1T:0P** 2 (one hour) lectures and one (one hour) tutorial per week. Only lecture hours are shown	**3 Credits**

Module 1. (2 hours)- Introduction

Purpose: To convey that Biology is as important a scientific discipline as Mathematics, Physics and Chemistry

Bring out the fundamental differences between science and engineering by drawing a comparison between eye and camera, Bird flying and aircraft. Mention the most exciting aspect of biology as an independent scientific discipline. Why we need to study biology? Discuss how biological observations of 18th Century that lead to major discoveries. Examples from Brownian motion and the origin of thermodynamics by referring to the original observation of Robert Brown and Julius Mayor. These examples will highlight the fundamental importance of observations in any scientific inquiry.

Module 2. (3 hours)- Classification

Purpose: To convey that classification *per se* is not what biology is all about. The underlying criterion, such as morphological, biochemical or ecological be highlighted.

Hierarchy of life forms at phenomenological level. A common thread weaves this hierarchy Classification. Discuss classification based on (a) cellularity- Unicellular or multicellular (b) ultrastructure- prokaryotes or eucaryotes. (c) energy and Carbon utilisation -Autotrophs, heterotrophs, lithotropes (d) Ammonia excretion – aminotelic, uricoteliec, ureotelic (e) Habitata- acquatic or terrestrial (e) Molecular taxonomy- three major kingdoms of life. A given organism can come under different category based on classification. Model organisms for the study of biology come from different groups. E.coli, S.cerevisiae, D. Melanogaster, C. elegance, A. Thaliana, M. musculus

Module 3. (4 hours)-Genetics

Purpose: To convey that "Genetics is to biology what Newton's laws are to Physical Sciences"

Mendel's laws, Concept of segregation and independent assortment. Concept of allele. Gene mapping, Gene interaction, Epistasis. Meiosis and Mitosis be taught as a part of genetics. Emphasis to be give not to the mechanics of cell division nor the phases but how genetic material passes from parent to offspring. Concepts of recessiveness and dominance. Concept of mapping of phenotype to genes. Discuss about the single gene disorders in humans. Discuss the concept of complementation using human genetics.

Module 4. (4 hours)-Biomolecules

Purpose: To convey that all forms of life has the same building blocks and yet the manifestations are as diverse as one can imagine

Molecules of life. In this context discuss monomeric units and polymeric structures. Discuss about sugars, starch and cellulose. Amino acids and proteins. Nucleotides and DNA/RNA. Two carbon units and lipids.

Module 5. (4 Hours). Enzymes
Purpose: To convey that without catalysis life would not have existed on earth
Enzymology: How to monitor enzyme catalysed reactions. How does an enzyme catalyse reactions? Enzyme classification. Mechanism of enzyme action. Discuss at least two examples. Enzyme kinetics and kinetic parameters. Why should we know these parameters to understand biology? RNA catalysis.

Module 6. (4 hours)- Information Transfer
Purpose: The molecular basis of coding and decoding genetic information is universal
Molecular basis of information transfer. DNA as a genetic material. Hierarchy of DNA structure- from single stranded to double helix to nucleosomes. Concept of genetic code. Universality and degeneracy of genetic code. Define gene in terms of complementation and recombination.

Module 7. (5 hours). Macromolecular analysis
Purpose: How to analyse biological processes at the reductionist level
Proteins- structure and function. Hierarch in protein structure. Primary secondary, tertiary and quaternary structure. Proteins as enzymes, transporters, receptors and structural elements.

Module 8. (4 hours)- Metabolism
Purpose: The fundamental principles of energy transactions are the same in physical and biological world.
Thermodynamics as applied to biological systems. Exothermic and endothermic versus endergonic and exergoinc reactions. Concept of K_{eq} and its relation to standard free energy. Spontaneity. ATP as an energy currency. This should include the breakdown of glucose to CO_2 + H_2O (Glycolysis and Krebs cycle) and synthesis of glucose from CO_2 and H_2O (Photosynthesis). Energy yielding and energy consuming reactions. Concept of Energy charge
Module 9. (3 hours)- Microbiology
Concept of single celled organisms. Concept of species and strains. Identification and classification of microorganisms. Microscopy. Ecological aspects of single celled organisms. Sterilization and media compositions. Growth kinetics.

References:

1) Biology: A global approach: Campbell, N. A.; Reece, J. B.; Urry, Lisa; Cain, M, L.; Wasserman, S. A.; Minorsky, P. V.; Jackson, R. B. Pearson Education Ltd
2) Outlines of Biochemistry, Conn, E.E; Stumpf, P.K; Bruening, G; Doi, R.H. John Wiley and Sons
3) Principles of Biochemistry (V Edition), By Nelson, D. L.; and Cox, M. M.W.H. Freeman and Company
4) Molecular Genetics (Second edition), Stent, G. S.; and Calender, R. W.H. Freeman and company, Distributed by Satish Kumar Jain for CBS Publisher
5) Microbiology, Prescott, L.M J.P. Harley and C.A. Klein 1995. 2nd edition Wm, C. Brown Publishers

Course Outcomes

After studying the course, the student will be able to:

Describe how biological observations of 18th Century that lead to major discoveries.
Convey that classification *per se* is not what biology is all about but highlight the underlying criteria, such as morphological, biochemical and ecological
Highlight the concepts of recessiveness and dominance during the passage of genetic material from parent to offspring
Convey that all forms of life have the same building blocks and yet the manifestations are as diverse as one can imagine
Classify enzymes and distinguish between different mechanisms of enzyme action.
Identify DNA as a genetic material in the molecular basis of information transfer.
Analyse biological processes at the reductionistic level
Apply thermodynamic principles to biological systems.
Identify and classify microorganisms.

All India Council for Technical Education
Mathematics Courses (Common)

MATHEMATICS 1 **Calculus and Linear Algebra**	**3L1T0P**	**4 CREDITS**

OBJECTIVES:

The objective of this course is to familiarize the prospective engineers with techniques in calculus, multivariate analysis and linear algebra. It aims to equip the students with standard concepts and tools at an intermediate to advanced level that will serve them well towards tackling more advanced level of mathematics and applications that they would find useful in their disciplines. More precisely, the objectives are:

- To introduce the idea of applying differential and integral calculus to notions of curvatureand to improper integrals. Apart from some applications it gives a basic introduction on Beta and Gamma functions.
- To introduce the fallouts of Rolle's Theoremthat is fundamental to application of analysis to Engineering problems.
- To develop the tool of power series and Fourier series for learning advanced Engineering Mathematics.
- To familiarize the student with functions of several variables that is essential in most branches of engineering.
- To develop the essential tool of matrices and linear algebra in a comprehensive manner.

Module 1: Calculus: (6 hours)
Evolutes and involutes~~;~~ Evaluation of definite and improper integrals; Beta and Gamma functions and their properties; Applications of definite integrals to evaluate surface areas and volumes of revolutions.

Module 2: Calculus: (6 hours)

Rolle's Theorem, Mean value theorems, Taylor's and Maclaurin theorems with remainders; indeterminate forms and L'Hospital's rule; Maxima and minima.

Module 3:Sequences and series: (10 hours)
Convergence of sequence and series, tests for convergence; Power series, Taylor's series, series for exponential, trigonometric and logarithm functions; Fourier series: Half range sine and cosine series, Parseval's theorem.

Module 4:Multivariable Calculus (Differentiation): (8 hours)

Limit, continuity and partial derivatives, directional derivatives, total derivative; Tangent plane and normal line; Maxima, minima and saddle points; Method of Lagrange multipliers; Gradient, curl and divergence.

Module 5:Matrices (10hours)

Inverse and rank of a matrix,rank-nullity theorem; System of linear equations; Symmetric, skew-symmetric and orthogonal matrices; Determinants; Eigenvalues and eigenvectors; Diagonalization of matrices; Cayley-Hamilton Theorem, and Orthogonal transformation.

Textbooks/References:

1. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Edition,Pearson, Reprint, 2002.
2. Erwin kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
3. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.
4. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11thReprint, 2010.
5. D. Poole, Linear Algebra: A Modern Introduction, 2nd Edition, Brooks/Cole, 2005.
6. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2008.
7. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36th Edition, 2010.

MATHEMATICS 2 **Calculus, Ordinary Differential Equations and Complex Variable**	**3L1T0P**	**4 CREDITS**

OBJECTIVES:

The objective of this course is to familiarize the prospective engineers with techniques in multivariate integration, ordinary and partial differential equations and complex variables.It aims to equip the studentsto deal with advanced level of mathematics and applications that would be essential for their disciplines. More precisely, the objectives are:

- To acquaint the student with mathematical tools needed in evaluating multiple integrals and their usage.
- To introduce effective mathematical tools for the solutions of differential equations that model physical processes.
- To introduce the tools of differentiation and integration of functions of complex variable that are used in various techniques dealing engineering problems.

Module 1:Multivariable Calculus (Integration): (10 hours)

Multiple Integration: Double integrals (Cartesian), change of order of integration in double integrals, Change of variables (Cartesian to polar), Applications: areas and volumes, Center of mass and Gravity (constant and variable densities);Triple integrals (Cartesian), orthogonal curvilinear coordinates, Simple applications involving cubes, sphere and rectangular parallelepipeds; Scalar line integrals, vector line integrals, scalar surface integrals, vector surface integrals, Theorems of Green, Gauss and Stokes.

Module 2:First order ordinary differential equations:(6 hours)
Exact, linear and Bernoulli's equations, Euler's equations, Equations not of first degree: equations solvable for p, equations solvable for y, equations solvable for x and Clairaut's type.

Module 3:Ordinary differential equations of higher orders:(8 hours)
Second order linear differential equations with variable coefficients, method of variation of parameters, Cauchy-Euler equation; Power series solutions; Legendre polynomials, Bessel functions of the first kind and their properties.

Module 4: Complex Variable – Differentiation:(8 hours):
Differentiation, Cauchy-Riemann equations, analytic functions, harmonic functions, finding harmonic conjugate; elementary analytic functions (exponential, trigonometric, logarithm) and their properties; Conformal mappings, Mobius transformations and their properties.

Module 5: Complex Variable – Integration:(8 hours):
Contour integrals, Cauchy-Goursat theorem (without proof), Cauchy Integral formula (without proof), Liouville's theorem and Maximum-Modulus theorem (without proof); Taylor's series, zeros of analytic functions, singularities, Laurent's series; Residues, Cauchy Residue theorem (without proof), Evaluation of definite integral involving sine and cosine, Evaluation of certain improper integrals using the Bromwich contour.

Textbooks/References:

1. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Edition, Pearson, Reprint, 2002.
2. Erwin kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
3. W. E. Boyce and R. C. DiPrima, Elementary Differential Equations and Boundary Value Problems, 9th Edn., Wiley India, 2009.
4. S. L. Ross, Differential Equations, 3rd Ed., Wiley India, 1984.
5. E. A. Coddington, An Introduction to Ordinary Differential Equations, Prentice Hall India, 1995.
6. E. L. Ince, Ordinary Differential Equations, Dover Publications, 1958.
7. J. W. Brown and R. V. Churchill, Complex Variables and Applications, 7th Ed., Mc-Graw Hill, 2004.
8. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2008.
9. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36th Edition, 2010.

MATHEMATICS 3	**3L0T0P**	**3 CREDITS**

This will be a need based customized course for different branches with modules chosen from the following:

1. Partial Differential Equations (5c, 5d)
2. Numerical Methods (Modules 7a, 7b)
3. Transform Calculus ((Modules 8a, 8b)
4. Discrete Mathematics (Modules 9a, 9b, 9c, 9d, 9e, 9f)
5. Probability and Statistics (Modules 10a, 10b, 10c, 10d, 10e, 10f)

If needed, there can be an additional Mathematics course:

MATHEMATICS 4: (2-0-0-2)

All India Council for Technical Education
Mathematics Courses, Option 2 (for CSE etc.)

Paper 1: Calculus and Linear Algebra (3-1-0-4)

Module 1: Calculus: (6 hours)
Evolutes and involutes; Evaluation of definite and improper integrals; Beta and Gamma functions and their properties; Applications of definite integrals to evaluate surface areas and volumes of revolutions.

Module 2: Calculus: (6 hours)
Rolle's theorem, Mean value theorems, Taylor's and Maclaurin theorems with remainders; Indeterminate forms and L'Hospital's rule; Maxima and minima.

Module 3:Matrices (in case vector spaces is to be taught) (8 hours)
Matrices, vectors: addition and scalar multiplication, matrix multiplication; Linear systems of equations, linear Independence, rank of a matrix, determinants, Cramer's Rule, inverse of a matrix, Gauss elimination and Gauss-Jordan elimination.

Module 4:Vector spaces (Prerequisite 4b) (10 hours)
Vector Space, linear dependence of vectors, basis, dimension; Linear transformations (maps), range and kernel of a linear map, rank and nullity, Inverse of a linear transformation, rank-nullity theorem, composition of linear maps, Matrix associated with a linear map.

Module 5:Vector spaces (Prerequisite 4b-c) (10 hours)
Eigenvalues, eigenvectors, symmetric, skew-symmetric, and orthogonal Matrices, eigenbases. Diagonalization; Inner product spaces, Gram-Schmidt orthogonalization.

Textbooks/References:

1. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Edition, Pearson, Reprint, 2002.
2. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
3. D. Poole, Linear Algebra: A Modern Introduction, 2nd Edition, Brooks/Cole, 2005.
4. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.
5. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11th Reprint, 2010.
6. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2010.
7. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition, 2000.
8. V. Krishnamurthy, V.P. Mainra and J.L. Arora, An introduction to Linear Algebra, Affiliated East–West press, Reprint 2005.

Paper 2: Probability and Statistics (3-1-0-4)

***Module 1:* Basic Probability:** (12 hours)
Probability spaces, conditional probability, independence; Discrete random variables, Independent random variables, the multinomial distribution, Poisson approximation to the binomial distribution, infinite sequences of Bernoulli trials, sums of independent random variables; Expectation of Discrete Random Variables, Moments, Variance of a sum, Correlation coefficient, Chebyshev's Inequality.

***Module 2:* Continuous Probability Distributions:** (4 hours)
Continuous random varibales and their properties, distribution functions and densities, normal, exponential and gamma densities.

***Module 3:* Bivariate Distributions:** (4 hours)
Bivariate distributions and their properties, distribution of sums and quotients, conditional densities, Bayes' rule.

Module 4: Basic Statistics: (8 hours)

Measures of Central tendency: Moments, skewness and Kurtosis - Probability distributions: Binomial, Poisson and Normal - evaluation of statistical parameters for these three distributions, Correlation and regression – Rank correlation

Module 5: Applied Statistics: (8 hours)
Curve fitting by the method of least squares- fitting of straight lines, second degree parabolas and more general curves. Test of significance: Large sample test for single proportion, difference of proportions, single mean, difference of means, and difference of standard deviations.

Module 6: Small samples: (4 hours)
Test for single mean, difference of means and correlation coefficients, test for ratio of variances - Chi-square test for goodness of fit and independence of attributes.

Textbooks/References:

1. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
2. P. G. Hoel, S. C. Port and C. J. Stone, Introduction to Probability Theory, Universal Book Stall, 2003 (Reprint).
3. S. Ross, A First Course in Probability, 6th Ed., Pearson Education India, 2002.
4. W. Feller, An Introduction to Probability Theory and its Applications, Vol. 1, 3rd Ed., Wiley, 1968.
5. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2010.
6. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition, 2000.
7. Veerarajan T., Engineering Mathematics (for semester III), Tata McGraw-Hill, New Delhi, 2010.

Paper 3: Calculus and Ordinary Differential Equations (3-0-0-3)

Module 1:Sequences and series: (Prerequisite 2b) (8 hours)

Convergence of sequence and series, tests for convergence, power series, Taylor's series. Series for exponential, trigonometric and logarithmic functions.

Module 2:Multivariable Calculus (Differentiation) (Prerequisite 2b) (8 hours)

Limit, continuity and partial derivatives, directional derivatives, total derivative; Tangent plane and normal line; Maxima, minima and saddle points; Method of Lagrange multipliers; Gradient, curl and divergence.

Module 3:Multivariable Calculus (Integration) (Prerequisite 3a) (10 hours)

Multiple Integration: double and triple integrals (Cartesian and polar), change of order of integration in double integrals, Change of variables (Cartesian to polar). Theorems of Green, Gauss and Stokes, orthogonal curvilinear coordinates, Simple applications involving cubes, sphere and rectangular parallelepipeds.

Module 4:First order ordinary differential equations(6 hours)

Exact, linear and Bernoulli’s equations, Euler’s equations, Equations not of first degree: equations solvable for p, equations solvable for y, equations solvable for x and Clairaut’s type.

Module 5:Ordinary differential equations of higher orders (8 hours)

Second order linear differential equations with variable coefficients, method of variation of parameters, Cauchy-Euler equation; Power series solutions; Legendre polynomials, Bessel functions of the first kind and their properties.

Textbooks/References:

1. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Edition, Pearson, Reprint, 2002.
2. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.
3. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11th Reprint, 2010.
4. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2010.
5. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition, 2000.
6. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
7. W. E. Boyce and R. C. DiPrima, Elementary Differential Equations and Boundary Value Problems, 9th Edition, Wiley India, 2009.
8. S. L. Ross, Differential Equations, 3rd Ed., Wiley India, 1984.
9. E. A. Coddington, An Introduction to Ordinary Differential Equations, Prentice Hall India, 1995.
10. E. L. Ince, Ordinary Differential Equations, Dover Publications, 1958.
11. G.F. Simmons and S.G. Krantz, Differential Equations, Tata McGraw Hill, 2007.

All India Council for Technical Education
Different Modules for Mathematics Courses

1. Algebra and Trigonometry (Optional)

Module 1a: Trigonometry: Hyperbolic and circular functions, logarithms of complex number, resolving real and imaginary parts of a complex quantity, De Moivre's Theorem.

Module 1b: Theory of equations: Relation between roots and coefficients, reciprocal equations, transformation of equations and diminishing the roots.

2. *Calculus (Single Variable)*

Module 2a: Calculus: (6 hours)

Evolutes and involutes; Evaluation of definite and improper integrals; Beta and Gamma functions and their properties; Applications of definite integrals to evaluate surface areas and volumes of revolutions.

Module 2b: Calculus: (6 hours)

Rolle's theorem, Mean value theorems, Taylor's and Maclaurin theorems with remainders; Indeterminate forms and L'Hospital's rule; Maxima and minima.

Module 2c:Sequences and series: (Prerequisite 2b) (10 hours)

Convergence of sequence and series, tests for convergence, power series, Taylor's series. Series for exponential, trigonometric and logarithmic functions; Fourier series: Half range sine and cosine series, Parseval's theorem.

Textbooks/References:

1. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Edition, Pearson, Reprint, 2002.
2. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.
3. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11th Reprint, 2010.
4. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2010.
5. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition, 2000.

3. *Multivariable Calculus*

Module 3a:Multivariable Calculus (Differentiation)(Prerequisite 2b) (10 hours)

Limit, continuity and partial derivatives, directional derivatives, total derivative; Tangent plane and normal line; Maxima, minima and saddle points; Method of Lagrange multipliers; Gradient, curl and divergence.

Module 3b:Multivariable Calculus (Integration)(Prerequisite 3a) (10 hours)

Multiple Integration: Double integrals (Cartesian), change of order of integration in double integrals, Change of variables (Cartesian to polar), Applications: areas and volumes, Center of mass and Gravity (constant and variable densities); Triple integrals (Cartesian), orthogonal curvilinear coordinates, Simple applications involving cubes, sphere and rectangular parallelepipeds; Scalar line integrals, vector line integrals, scalar surface integrals, vector surface integrals, Theorems of Green, Gauss and Stokes.

Textbooks/References:

1. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Edition, Pearson, Reprint, 2002.
2. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.
3. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11th Reprint, 2010.
4. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2010.
5. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition, 2000.

4. *Matrices and Linear Algebra*

Module 4a:Matrices (in case vector spaces is not to be taught)(14 hours)

Algebra of matrices, Inverse and rank of a matrix, rank-nullity theorem; System of linear equations; Symmetric, skew-symmetric and orthogonal matrices; Determinants; Eigenvalues and eigenvectors; Diagonalization of matrices; Cayley-Hamilton Theorem, Orthogonal transformation and quadratic to canonical forms.

Module 4b:Matrices (in case vector spaces is to be taught) (8 hours)

Matrices, vectors: addition and scalar multiplication, matrix multiplication; Linear systems of equations, linear Independence, rank of a matrix, determinants, Cramer’s Rule, inverse of a matrix,Gauss elimination and Gauss-Jordan elimination.

Module 4c:Vector spaces (Prerequisite 4b) (10 hours)

Vector Space,linear dependence of vectors, basis, dimension; Linear transformations (maps), range and kernel of a linear map, rank and nullity, Inverse of a linear transformation, rank-nullity theorem, composition of linear maps, Matrix associated with a linear map.

Module 4d:Vector spaces (Prerequisite 4b-c) (10 hours)

Eigenvalues, eigenvectors, symmetric, skew-symmetric, and orthogonal Matrices, eigenbases. Diagonalization; Inner product spaces, Gram-Schmidt orthogonalization.

Textbooks/References:

1. D. Poole, Linear Algebra: A Modern Introduction, 2nd Edition, Brooks/Cole, 2005.
2. V. Krishnamurthy, V.P. Mainra and J.L. Arora, An introduction to Linear Algebra, Affiliated East–West press, Reprint 2005.
3. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.

4. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.
5. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2010.
6. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition, 2000.

5. ***Differential equations***(Prerequisite Sections 2 and 3)

Module 5a:First order ordinary differential equations(6 hours)

Exact, linear and Bernoulli's equations, Euler's equations, Equations not of first degree: equations solvable for p, equations solvable for y, equations solvable for x and Clairaut's type.

Module 5b:Ordinary differential equations of higher orders (Prerequisite 2c, 4a) (8 hours)

Second order linear differential equations with variable coefficients, method of variation of parameters, Cauchy-Euler equation; Power series solutions; Legendre polynomials, Bessel functions of the first kind and their properties.

Textbooks/References:

1. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
2. W. E. Boyce and R. C. DiPrima, Elementary Differential Equations and Boundary Value Problems, 9th Edition, Wiley India, 2009.
3. S. L. Ross, Differential Equations, 3rd Ed., Wiley India, 1984.
4. E. A. Coddington, An Introduction to Ordinary Differential Equations, Prentice Hall India, 1995.
5. E. L. Ince, Ordinary Differential Equations, Dover Publications, 1958.
6. G.F. Simmons and S.G. Krantz, Differential Equations, Tata McGraw Hill, 2007.

Module 5c:Partial Differential Equations – First order(Prerequisite 5a-b) (6 hours)

First order partial differential equations, solutions of first order linear and non-linear PDEs.

Module 5d**: **Partial Differential Equations– **Higher order**(Prerequisite 5b-c) (10 hours)

Solution to homogenous and non-homogenous linear partial differential equations second and higher order by complimentary function and particular integral method.

Flows, vibrations and diffusions, second-order linear equations and their classification, Initial and boundary conditions (with an informal description of well-posed problems), D'Alembert's solution of the wave equation; Duhamel's principle for one dimensional wave equation.

Separation of variables method to simple problems in Cartesian coordinates. The Laplacian in plane, cylindrical and spherical polar coordinates, solutions with Bessel functions and Legendre functions. One dimensional diffusion equation and its solution by separation of variables.

Boundary-value problems: Solution of boundary-value problems for various linear PDEs in various geometries.

1. S. J. Farlow, Partial Differential Equations for Scientists and Engineers, Dover Publications, 1993.

2. R. Haberman, Elementary Applied Partial Differential equations with Fourier Series and Boundary Value Problem, 4th Ed., Prentice Hall, 1998.
3. Ian Sneddon, Elements of Partial Differential Equations, McGraw Hill, 1964.
4. Manish Goyal and N.P. Bali, Transforms and Partial Differential Equations, University Science Press, Second Edition, 2010.

6.Complex Variables(Prerequisite 2a-c)

Module 6a: Complex Variable – Differentiation(Prerequisite 2a-c) (8 hours):
Differentiation, Cauchy-Riemann equations, analytic functions, harmonic functions, finding harmonic conjugate; elementary analytic functions (exponential, trigonometric, logarithm) and their properties; Conformal mappings, Mobius transformations and their properties.

Module 6b: Complex Variable - Integration(Prerequisite 6a) (8 hours):
Contour integrals, Cauchy-Goursat theorem (without proof), Cauchy Integral formula (without proof), Liouville's theorem and Maximum-Modulus theorem (without proof); Taylor's series, zeros of analytic functions, singularities, Laurent's series; Residues, Cauchy Residue theorem (without proof), Evaluation of definite integral involving sine and cosine, Evaluation of certain improper integrals using the Bromwich contour.

Module 6c:Applications of complex integration by residues: (Prerequisite 2a, 6b) (4 hours)
Evaluation of definite integral involving sine and cosine. Evaluation of certain improper integrals using the Bromwich contour.

Textbooks/References:

1. Erwin kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
2. J. W. Brown and R. V. Churchill, Complex Variables and Applications, 7th Ed., Mc-Graw Hill, 2004.
3. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.
4. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2010.
5. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition, 2000.

7. Numerical Methods

Module 7a: Numerical Methods – 1 (Prerequisite 2a)(12 hours)
Solution of polynomial and transcendental equations – Bisection method, Newton-Raphson method and Regula-Falsi method. Finite differences, Relation between operators,Interpolation using Newton's forward and backward difference formulae. Interpolation with unequal intervals: Newton's divided difference and Lagrange'sformulae. Numerical Differentiation, Numerical integration: Trapezoidal rule and Simpson's 1/3rd and 3/8 rules.

Module 7b: Numerical Methods – 2 (Prerequisite 7a, 5a-d)(10 hours)

Ordinary differential equations: Taylor's series, Euler and modified Euler's methods. Runge-Kutta method of fourth order for solving first and second order equations. Milne's and Adam's predicator-corrector methods.

Partial differential equations: Finite difference solution two dimensional Laplace equation and Poission equation, Implicit and explicit methods for one dimensional heat equation (Bender-Schmidt and Crank-Nicholson methods), Finite difference explicit method for wave equation.

Textbooks/References:

1. P. Kandasamy, K. Thilagavathy, K. Gunavathi, Numerical Methods, S. Chand & Company, 2nd Edition, Reprint 2012.
2. S.S. Sastry, Introductory methods of numerical analysis, PHI, 4th Edition, 2005.
3. Erwin kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
4. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition, 2010.

8. Transform Calculus

***Module 8a:Transform Calculus*-1** (Prerequisite 2c, 5b-d, 6b) (10 hours)

Polynomials – Orthogonal Polynomials – Lagrange's, Chebysev Polynomials; Trigonometric Polynomials;

Laplace Transform, Properties of Laplace Transform, Laplace transform of periodic functions. Finding inverse Laplace transform by different methods, convolution theorem. Evaluation of integrals by Laplace transform, solving ODEs and PDEs by Laplace Transform method.

***Module 8b:Transform Calculus*-2** (10 hours)

Fourier transforms, Z-transform and Wavelet transforms:properties, methods, inverses and their applications.

Textbooks/References:

1. Erwin kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
2. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2010.
3. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition, 2000.
4. Veerarajan T., Engineering Mathematics, Tata McGraw-Hill, New Delhi, 2008.

9. Discrete Mathematics

***Module 9a:Sets, relations and functions*:** (8 hours)

Basic operations on sets, Cartesian products, disjoint union (sum), and power sets. Different types of relations, their compositions and inverses. Different types of functions, their compositions and inverses.

Module 9b:Propositional Logic: (6 hours)

Syntax and semantics, proof systems, satisfiability, validity, soundness, completeness, deduction theorem, etc. Decision problems of propositional logic. Introduction to first order logic and first order theory.

Module 9c:Partially ordered sets: (6 hours)

Complete partial ordering, chain, lattice, complete, distributive, modular and complemented lattices. Boolean and pseudo Boolean lattices.

Module 9d:Algebraic Structures: (6 hours)

Algebraic structures with one binary operation – semigroup, monoid and group. Cosets, Lagrange’s theorem, normal subgroup, homomorphic subgroup. Congruence relation and quotient structures. Error correcting code. Algebraic structures with two binary operations- ring, integral domain, and field. Boolean algebra and boolean ring (Definitions and simple examples only).

Module 9e:Introduction to Counting:(6 hours)

Basic counting techniques – inclusion and exclusion, pigeon-hole principle, permutation, combination, summations. Introduction to recurrence relation and generating functions.

Module 9f:Introduction to Graphs: (8 hours)

Graphs and their basic properties – degree, path, cycle, subgraph, isomorphism, Eulerian and Hamiltonian walk, trees.

Textbooks/References:

1. C. L. Liu, Elements of Discrete Mathematics, 2nd Ed., Tata McGraw-Hill, 2000.
2. R. C. Penner, Discrete Mathematics: Proof Techniques and Mathematical Structures, World Scientific, 1999.
3. R. L. Graham, D. E. Knuth, and O. Patashnik, Concrete Mathematics, 2nd Ed., Addison-Wesley, 1994.
4. K. H. Rosen, Discrete Mathematics and its Applications, 6th Ed., Tata McGraw-Hill, 2007.
5. J. L. Hein, Discrete Structures, Logic, and Computability, 3rd Ed., Jones and Bartlett, 2010.
6. N. Deo, Graph Theory, Prentice Hall of India, 1974.
7. S. Lipschutz and M. L. Lipson, Schaum's Outline of Theory and Problems of Discrete Mathematics, 2nd Ed., Tata McGraw-Hill, 1999.
8. J. P. Tremblay and R. P. Manohar, Discrete Mathematics with Applications to Computer Science, Tata McGraw-Hill, 1997.

10. *Probability Theory and* Statistics

Probability Theory

Module 10a: **Basic Probability:** (12 hours)

Probability spaces, conditional probability, independence; Discrete random variables, Independent random variables, the multinomial distribution, Poisson approximation to the binomial distribution, infinite sequences of Bernoulli trials, sums of independent random variables; Expectation of Discrete Random Variables, Moments, Variance of a sum, Correlation coefficient, Chebyshev's Inequality.

Module 10b: **Continuous Probability Distributions:** (4 hours)

Continuous random varibales and their properties, distribution functions and densities, normal, exponential and gamma densities.

Module 10c: **Bivariate Distributions:** (4 hours)

Bivariate distributions and their properties, distribution of sums and quotients, conditional densities, Bayes' rule.

Textbooks/References:

1. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
2. P. G. Hoel, S. C. Port and C. J. Stone, Introduction to Probability Theory, Universal Book Stall, 2003 (Reprint).
3. S. Ross, A First Course in Probability, 6th Ed., Pearson Education India, 2002.
4. W. Feller, An Introduction to Probability Theory and its Applications, Vol. 1, 3rd Ed., Wiley, 1968.

Statistics

Module 10d: Basic Statistics: (8 hours)

Measures of Central tendency: Moments, skewness and Kurtosis - Probability distributions: Binomial, Poisson and Normal - evaluation of statistical parameters for these three distributions, Correlation and regression – Rank correlation.

Module 10e: Applied Statistics: (8 hours)

Curve fitting by the method of least squares- fitting of straight lines, second degree parabolas and more general curves. Test of significance: Large sample test for single proportion, difference of proportions, single mean, difference of means, and difference of standard deviations.

Module 10f: Small samples: (4 hours)

Test for single mean, difference of means and correlation coefficients, test for ratio of variances - Chi-square test for goodness of fit and independence of attributes.

Textbooks/References:

1. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
2. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2010.
3. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition, 2000.
4. Veerarajan T., Engineering Mathematics (for semester III), Tata McGraw-Hill, New Delhi, 2010.

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