Model Curriculum for UG Degree Course in

Electrical Engineering

(Engineering & Technology)

2024

ALL INDIA COUNCIL FOR TECHNICAL EDUCATION

Nelson Mandela Marg, Vasant Kunj, New Delhi 110070

www.aicte-india.org

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MESSAGE

It gives me immense pleasure to announce the launch of the *Model Curriculum for Electrical Engineering* at the undergraduate level. This initiative represents a significant step forward in AICTE's ongoing commitment to fostering excellence and innovation in technical education across India.

The Electrical Engineering curriculum has been meticulously designed in consultation with leading academicians, industry experts, and practitioners. It aims to address the evolving needs of the energy and power sectors while ensuring alignment with the vision of *Atmanirbhar Bharat* and global standards. This curriculum integrates modern industry practices, sustainability, and emerging technologies such as renewable energy, smart grids, and energy storage solutions.

A key focus of the curriculum is to develop competencies that enable students to tackle real-world challenges. It emphasizes a hands-on approach through practical training, internships, and project-based learning. By equipping students with critical thinking, problem-solving skills, and an entrepreneurial mindset, the curriculum prepares them to contribute meaningfully to the nation's development.

The curriculum is structured within a cumulative framework of **176 credits**, encompassing core engineering courses, discipline-specific advanced topics, and a variety of electives, including interdisciplinary and emerging areas. The integration of experiential learning, industry internships, and hands-on projects ensures students gain practical insights and industry-ready competencies. Designed to foster innovation, sustainability, and ethical practices, the curriculum emphasizes critical thinking, problem-solving abilities, and effective communication skills, shaping well-rounded engineers capable of addressing real-world challenges.

In alignment with AICTE's vision, the curriculum also offers opportunities for advanced academic achievement through Honours and Research tracks. These pathways encourage students to delve deeper into specialized domains of electrical engineering, promoting academic excellence and contributing to cutting-edge research and innovation.

Additionally, a three-week mandatory induction program has been designed for students at the beginning of their course. This program aims to acclimatize students to their new environment, instill a sense of belonging, and nurture an awareness of self, society, and nature while encouraging a balanced and healthy routine.

AICTE expresses its gratitude to the esteemed members of the expert committee whose invaluable contributions have shaped this comprehensive curriculum:

- **Prof. Prem Kumar Karla**, Ex Vice-Chancellor, Deen Dayal Bagh (Chairperson)
- **Prof. Sandeep Yadav**, IIT Jodhpur (Member)
- **Prof. S.P. Das**, IIT Kanpur (Member)
- **Prof. I.N. Kar**, IIT Delhi (Member)
- **Sh. Sahab Saran M.**, Founder Director, Ateliers Francois Compressors India, Pune (Member)
- **Sh. G Jayaram Pillai**, Head of APAC Operations, Zurich Instruments, Zurich (Member)
- **Sh. Gaurav Mathur**, Executive Director, EMU, Research Design and Standardization Organization (RDSO), Indian Railways, Lucknow (Member)

Their collective efforts have ensured that this Model Curriculum meets the demands of the modern technological landscape and fosters the growth of skilled, innovative, and socially responsible engineers.

As we usher in this new curriculum, I encourage institutions to adopt and implement it effectively. Together, let us empower the next generation of electrical engineers to innovate and lead in the field of technology and energy solutions.

We strongly encourage institutions, universities, and technical education boards across India to adopt this Model Curriculum at the earliest. While this is a suggestive framework, institutions are encouraged to exercise flexibility in tailoring the curriculum to their specific academic needs within the prescribed credit structure.

Together, let us work towards empowering the next generation of engineers to lead with knowledge, innovation, and purpose.

Sd/-
(Prof. T G Sitharam)
Chairman, AICTE

Committee for Model Curriculum

S.No	Name and Organisation	Designation
1	Prof Prem Kumar Karla,Ex VC Deen Dayal Bagh	Chairperson
2	Prof Sandeep Yadav,IIT Jodhpur	Member
3	Prof S.P. Das,IIT Kanpur	Member
4	Prof. I.N.Kar,IIT Delhi	Member
5	Sh. Sahab Saran M.,Founder Director , Ateliers Francois Compressors India , Pune	Member
6	Sh. G Jayaram Pillai -Member,Head of APAC operations, Zurich Instruments, Zurich	Member
7	Sh. Gaurav Mathur,,Executive Director, EMU, Research Design and Standardization Organization (RDSO), Indian Railways, Lucknow	Member

AICTE Officials: -

Name	Designation and Organisation
Dr. Mamta Rani Agarwal (up to June 2024)	Advisor, Policy and Academic Planning Bureau
Dr. Dinesh Singh (up to October 2024)	Director, Policy and Academic Planning Bureau
Dr. Amit Dutta (since October 2024)	Director, Policy and Academic Planning Bureau
Shri M.G. Vamsi Krishna (up to October 2024)	Deputy Director, Policy and Academic Planning Bureau
Shri Rakesh Kumar Pandit	Young Professional, Policy and Academic Planning Bureau

Contents

GENERAL COURSE STRUCTURE & CREDIT DISTRIBUTION

GENERAL COURSE STRUCTURE & THEME

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 Credit
2 Hours Practical (P) per week	1 Credit

B. Range of Credits:

In the light of the fact that a typical Model Four-year Undergraduate degree program in Engineering has about 176 credits, the total number of credits proposed for the four-year B. Tech/B.E. in Electrical Engineering is kept as **176**.

C. Structure of UG Program in Electrical Engineering:

The structure of UG program in Electrical Engineering shall have essentially the following categories of courses with the breakup of credits as given:

S. No.	Category	Breakup of Credits
1.	Humanities & Social Science Courses	12*
2.	Basic Science Courses	32*
3.	Engineering Science Courses	29*
4.	Program Core Courses (Branch specific)	64*
5.	Program Elective Courses (Branch specific)	15*
6.	Open Elective Courses (from Humanities, Technical Emerging or other Subjects)	9*
7.	Project work, Seminar and Internship in Industry or elsewhere	15*
8.	Audit Courses [Environmental Sciences, Indian Constitution]	(non-credit)
	TOTAL	**176**

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

D. Course code and definition:

Course code	Definitions
L	Lecture
T	Tutorial
P	Practical
HS	Humanities & Social Science Courses
BS	Basic Science Courses
ES	Engineering Science Courses
PC	Program Core Courses
PE	Program Elective Courses
OE	Open Elective Courses
AU	Audit Courses
EEC	Employment Enhancement Courses (Project/Summer Internship/Seminar)

- **Course level coding scheme**

Three-digit number (odd numbers are for the odd semester courses and even numbers are for even semester courses) used as suffix with the Course Code for identifying the level of the course. Digit at hundred's place signifies the year in which course is offered. e.g.

101, 102 … etc. for first year.

201, 202 …. Etc. for second year.

301, 302 … for third year.

- **Course Level/Duration/System**:

Undergraduate / Three or Four years/6 or 8 Semesters with multiple entry and exit. The following option will be made available to the students joining Electrical Engineering Program:

A. **One year:** Under Graduate Certificate in Electrical Engineering
B. **Two years**: Under Graduate Diploma in Electrical Engineering
C. **Three years**: Bachelor of Vocational in Electrical Engineering (B.Voc.)
D. **Four years**: Bachelor of Engineering / Bachelor of Technology (B.E/B.Tech) in Electrical Engineering

Concept of Minor Degree

All branches of Engineering and Technology shall offer Elective Subjects in the Emerging/ Multidisciplinary/ Region Specific Areas as specified in the Approval Process Hand book (APH).

a. Undergraduate Degree Subjects in Emerging / Multidisciplinary/ Region Specific Areas shall be allowed as specialization from the same department. The minimum additional Credits for such areas shall be in the range of 18-20 (including credit transferred from the SWAYAM platform) and the same shall be mentioned in the degree certificate, as specialization in that particular area. For example, doing extra credits for Cyber Security in Computer Science and Engineering shall earn B.E./B.Tech. (Hons.) Computer Science and Engineering with specialization in Cyber Security.

b. Minor specialization may be allowed in any Undergraduate Degree Courses where a student of another Department shall take the minimum additional Credits in the range of 18-20 and get a degree with a minor from another Department.

c. **AICTE approval is not required for offering Minor Degree/Hons. in any such area**, however the criteria is "Minor Degree or Hons. will cumulatively require additional 18 to 20 credits in the specified area in addition to the credits essential for obtaining the Undergraduate Degree in Major Discipline (i.e. 160 credits)".

Concept of Micro Credits / Micro Specialization

Micro Credits can be applied across various disciplines, including technical skills, soft skills, interdisciplinary topics, and emerging fields such as AI, data science, sustainability, and entrepreneurship.

Micro Credits are small, modular units of learning that allow students to gain specific skills or knowledge in a short time. These credits can be accumulated and used to meet the requirements for a diploma, undergraduate, or postgraduate degree.

Besides the core courses, programs normally have professional elective courses. Each HEI decides the electives it can or wishes to offer. In some areas may be desirable to organize a set of electives as micro specializations. A micro-specialization is to provide a limited specialization in some sub-area of various disciplines, by offering suitable electives. The goal of the micro specialization is to provide deeper understanding and skill development in that area, and can provide multiple pathways to students, as different students can graduate with

different specializations (or not). The areas in which micro specialization are offered should be aligned to industry careers or higher studies. A micro specialization for various disciplines may be defined as follows:

- It has a core course as the head (starting) course for the micro specialization
- It has a clearly defined goal, and learning outcomes for the goal
- It can have 2 +/- 0.5 additional courses (besides the head course) in the sub-area aligned to the goal.

These courses can be full course (4-credits) or half-course (2 credit), and can be taken as electives by students (or extra credits.)
Institutions can replace or add a course aligned to the micro specialization goal and also define a set of courses for a micro specialization and require that a subset be taken, with perhaps one being compulsory. It should be added that HEIs are completely free to decide whether to offer micro specializations or not, and if they decide to offer, which areas to provide the specialization in. How the micro specialization is to be reflected in a student's records/certificates is also to be decided entirely by HEIs based on their policies and practices.
Multiple pathways: For supporting multiple pathways within the academic program, we propose to provide for micro specializations through thematic course streams. These can be further enhanced by HEIs with programs like honors for advanced students with more credits or advanced learning outcomes, etc.

Benefits of Integrating Micro Credits:

- Enhanced Learning Flexibility: Students can choose from a wide array of micro-courses, allowing them to tailor their education to their career goals and interests.
- Skill Development: Micro Credits focus on specific, practical skills that are immediately applicable in the workplace, enhancing employability.
- Lifelong Learning: Micro Credits support continuous learning, making it easier for students and professionals to upskill or reskill in response to industry changes.
- Global Recognition: Micro Credits can often be recognized across institutions and countries, allowing students to study globally and transfer credits easily.

INDUCTION PROGRAM

The Essence and Details of Induction program can also be understood from the 'Detailed Guide on Student Induction program', as available on AICTE Portal,

(Link:https://www.aicteindia.org/sites/default/files/Detailed%20Guide%20on%20Student%2 0Induction%20program.pdf).

For more, Refer **Appendix III.**

Induction program (mandatory)	Three-week duration
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 • Familiarisation to Dept./Branch & Innovations

E. Mandatory Visits/ Workshop/Expert Lectures:

a. It is mandatory to arrange one industrial visit every semester for the students of each branch.

b. It is mandatory to conduct a One-week workshop during the winter break after fifth semester on professional/ industry/ entrepreneurial orientation.

c. It is mandatory to organise at least one expert lecture per semester for each branch by inviting resource persons from domain specific industry.

F. Evaluation Scheme (Suggestive only):

a. For Theory Courses:

(The weightage of internal assessment and end semester exam should be 30-40% and 60-70% respectively)

The student has to obtain at least 40% marks individually both in internal assessment and end semester exams to pass.

b. For Practical Courses:

(The weightage of the internal assessment and end-semester exam should be 50-60% and 40-50% respectively)

The student has to obtain at least 40% marks individually both in internal assessment and end-semester exams to pass.

G. For Summer Internship / Projects / Seminar etc.

Evaluation is based on work done, quality of report, performance in viva voce, presentation etc.

Note: The internal assessment is based on the student's performance in mid-semester tests (two best out of three), quizzes, assignments, class performance, attendance, viva- voce in practical, lab record etc.

H. Mapping of Marks to Grades

Each course (Theory/Practical) is to be assigned 100 marks, irrespective of the number of credits, and the mapping of marks to grades may be done as per the following table:

Range of Marks	**Assigned Grade**
91-100	AA/A^+
81-90	AB/A
71-80	BB/B^+
61-70	BC/B
51-60	CC/C^+
46-50	CD/C
40-45	DD/D
< 40	FF/F (Fail due to less marks)
-	F^R (Fail due to shortage of attendance and therefore, to repeat the course)

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Semester-wise Structure and Curriculum for UG Degree Course in Electrical Engineering

SEMESTER I

SEMESTER I						
S. No.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
3 WEEKS COMPULSORY INDUCTION PROGRAM (UHV-I)						
1	BS-01	Physics(Any one from 5)	3	1	2	5
2	BS-02	Mathematics-I	3	1	0	4
3	ES-01	Basic Electrical Engineering	2	1	2	4
4	ES-02	Engineering Graphics & Design	1	0	4	3
5	HSM-01	English for Technical Writing	2	0	2	3
6	ES-03	Design Thinking	0	0	2	1
7	AU-01^	IDEA Lab Workshop	2	0	4	0
8	AEC103*	Additional Course - Indian or Foreign Language 1-1-0)) [optional course]*	1	1	0	0*
		TOTAL	**13**	**3**	**16**	**20**

*Indian Languages: Sanskrit/Hindi/All Regional Languages Foreign etc.

Languages: Spanish/German/French/Korean/Mandarin

SEMESTER II

S. No.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1	BS102	Chemistry I	3	0	2	4
2	BS104	Mathematics-II	3	1	0	4
3	ES104	Programming for Problem Solving	2	0	4	4
4	BS105	Biology for Engineers	3	0	0	3
5	ES105	Workshop/Manufacturing Practices	0	0	4	2
6	HSM-02	Universal Human Values	2	1	0	3
7	AU-02^	Yoga/Sports/NCC/NSS/Disaster Management	2	0	0	0
8	AEC103	Additional Course - Indian or Foreign Language (1-1-0) [optional course]*	1	1	0	0*
TOTAL			**15**	**2**	**10**	**20**

^ represent “Audit Course”.

An UNDER GRADUATE CERTIFICATE IN ELECTRICAL ENGINEERING will be awarded, if a student wishes to exit at the end of First year.

Exit Criteria after First Year of Electrical Engineering

Students will have the option to exit the Electrical Engineering program after successfully completing the first year. Upon exit, they will be awarded a *Undergraduate Certificate in Electrical Engineering*. To qualify for this exit option, students must also complete an additional 10 credits through one of the following pathways, as decided by the respective University or Admitting Body:

1. **Skill-based Subject:** A course designed to impart industry-relevant skills in Electrical Engineering.
2. **Work-based Vocational Course:** Practical hands-on training in a vocational area relevant to Electrical Engineering, offered during the summer term.
3. **Internship/Apprenticeship:** A minimum 8-week internship or apprenticeship in a relevant Electrical Engineering domain, providing exposure to real-world applications.
4. **Social Responsibility & Community Engagement:** A community-based project involving active engagement with an NGO or similar organization, aimed at applying Electrical knowledge for social benefit.

This additional credit requirement must be fulfilled after the second semester and is essential for ensuring that students develop both technical skills and practical experience, enhancing their employability even at the certificate level.

- The exiting students will clear the subject / submit the Internship Report as per the University schedule.

Re-entry Criteria in to Second Year (Third Semester)

The student who takes an exit after one year with an award of certificate may be allowed to re-enter in to Third Semester for completion of the Electrical Engineering Program as per the respective University /Admitting Body schedule after earning requisite credits in the First year.

SEMESTER III

S. No	Course Code	Course Title	L	T	P	C
1	HS201	Effective Technical Communication	3	0	0	3
2	PCC201	Analog Electronics	3	1	2	5
3	PCC202	Information and Signals	3	1	0	4
4	PCC203	Network Analysis	3	1	2	5
5	PCC204	Electrical Machines-I	3	1	2	5
6	PEC201	Engineering Mechanics	3	1	0	4
7	HSMC201	NEP Credits (Indian Knowledge Systems/ Management/HSS/ Entrepreneurship/Interdisciplinary course like Thermodynamics, Fluid Dynamics)				3
TOTAL						29

SEMESTER IV

S. No.	Course Code	Course Title	L	T	P	C
1	AU202	Environmental Science	3	0	0	0
2	PCC206	Digital Electronics	3	1	2	5
3	PCC207	Control Systems	3	1	2	5
4	PCC208	Power Electronics	3	1	2	5
5	PCC209	Electromagnetic Fields	3	1	0	4
6	PEC202	Departmental Elective	3	1	0	4
7	HSMC202	NEP Credits (Indian Knowledge Systems/ Management/HSS/ Technical Communication/ Entrepreneurship/Interdisciplinary course like Thermodynamics, Fluid Dynamics)				3
8	EEC 201	Summer Internship I				-
TOTAL						**26**

Bouquet for Professional Electives (PEC) 2nd Year (L T P C)

Sl.No.	Course	L	T	P	C
1	Electrical Machines-II	3	1	0	4
2	Digital Signal Processing	3	1	0	4

Exit Criteria after Second Year of Electrical Engineering

Students will have the option to exit the Electrical Engineering program after successfully completing the second year. Upon exit, they will be awarded a *Undergraduate Diploma in Electrical Engineering*. To qualify for this exit option, students must also complete an additional 10 credits through one of the following pathways, as determined by the respective University or Admitting Body:

1. **Skill-based Subject:** A course focused on developing advanced technical skills in Electrical Engineering, designed to meet industry demands.
2. **Work-based Vocational Course:** Practical training in a relevant vocational field offered during the summer term, providing hands-on experience.
3. **Internship/Apprenticeship:** A minimum 8-week internship or apprenticeship in an Electrical Engineering-related field, aimed at enhancing practical knowledge and industry exposure.
4. **Social Responsibility & Community Engagement:** Participation in a community-based project with an NGO or similar organization, applying engineering solutions to societal challenges.
5. **Capstone Project:** Completion of a capstone project that synthesizes the knowledge and skills acquired during the first two years of the program, showcasing problem-solving and technical abilities.

In addition to these options, exiting students must clear the associated subject(s) or submit the internship/apprenticeship report, as per the schedule and guidelines provided by the University or Admitting Body.

This structured exit option ensures that students acquire both theoretical knowledge and practical skills, making them industry-ready even with a diploma-level qualification.

Re-entry Criteria in to Third Year (Fifth Semester)

The student who takes an exit after second year with an award of Diploma may be allowed to re-enter in to fifth Semester for completion of the Electrical Engineering Program as per the respective University / Admitting Body schedule after earning requisite credits in the Second year.

SEMESTER V

S. No.	Course Code	Course Title	L	T	P	C
1	HS301	Entrepreneurship and Startups	3	0	0	3
2	AU301	Indian Constitution	3	0	0	0
3	PE301	Building Cyber Physical Systems	3	0	2	4
4	PCC301	Power Systems-I	3	1	2	5
5	PE302	Mechatronics/ New and Renewable Energy	3	1	2	5
6	OE301	Computer Architecture	3	1	2	5
7	PE303	Communication Systems	3	1	0	4
TOTAL						**26**

^ represents "Audit Course".

SEMESTER VI

S. No.	Course Code	Course Title	L	T	P	C
1	PE304	DEL-4 (Power Systems-II/Electrical Safety/Electric Vehicles)	3	1	0	4
2	PC301	Measurements and Instrumentation	3	1	2	5
3	PE303 / PC302	(Introduction to Robotics and Automation/ Microprocessor and Microcontrollers	3	1	0	4
4	OE302	GNEL-7 (HSS)	3	1	0	4
5	PE304	DEL-5	3	1	0	4
6	EEC301	Summer Internship II / Minimum duration of 1 month internship in industry/ Design credit during the summer vacation				
TOTAL						**22**

Bouquet Professional Electives (PEC) 3rd Year

Sl. No.	Course	L	T	P	C
1	Power Systems-II	3	1	0	4
2	VLSI Design	3	0	0	3
3	Biosensors	3	0	2	4

4	Modern Control System Multivariable Control	3	0	0	3
5	Information Theory and Coding	3	0	0	3
6	Digital Signal Processing	3	0	0	3
7	Embedded Systems	3	0	0	3
8	Building Cyber Physical Systems	3	0	2	4
9	Mechatronics	3	1	2	5
10	New and Renewable Energy	3	1	2	5
11	Electric Safety	3	1	2	5
12	Electric Vehicles	3	1	2	5
13	Introduction to Robotics and Automation	3	1	2	5

Exit Criteria after Third Year of Electrical Engineering

Students will have the option to exit the Electrical Engineering program after successfully completing the third year. Upon exit, they will be awarded a *Bachelor of Vocation (B.Voc.) in Electrical Engineering*. This degree is designed to recognize the technical expertise and vocational skills acquired during the first three years of the program, making graduates highly employable in the industry.

To qualify for this exit option, students must demonstrate proficiency in both theoretical and practical aspects of Electrical Engineering through:

1. **Completion of Core Courses:** Successful completion of all core courses in the Electrical Engineering curriculum for the first three years.
2. **Practical Training:** Participation in industry-relevant practical training, internships, or apprenticeships that equip students with hands-on experience in the field.
3. **Capstone Project (Optional):** Completion of a capstone project that integrates the knowledge and skills acquired throughout the program, showcasing problem-solving and innovation in Electrical Engineering.
4. **Skill-based Subject:** A course focused on developing advanced technical skills in Electrical Engineering, designed to meet industry demands.
5. **Internship/Apprenticeship:** A minimum 8-week internship or apprenticeship in an Electrical Engineering-related field, aimed at enhancing practical knowledge and industry exposure.

6. **Social Responsibility & Community Engagement:** Participation in a community-based project with an NGO or similar organization, applying engineering solutions to societal challenges.

This exit pathway provides a strong foundation in Electrical Engineering, emphasizing vocational and practical skills while maintaining academic rigor. Graduates will be well-positioned for roles in various industries, including Electrical design projects, maintenance, manufacturing, and more, or may choose to continue their education for higher qualifications.

Re-entry Criteria in to Fourth Year (Seventh Semester)

The student who takes an exit after third year with an award of Electrical Engineering may be allowed to re-enter in to Seventh Semester for completion of the Electrical Engineering Program as per the respective University / Admitting Body schedule after earning requisite credits in the Third year.

SEMESTER VII

S. No.	Course Code	Course Title	L	T	P	C
1	OE401	Open Elective III (Emerging Areas)	3	0	0	3
2	EEC401	Design Major Project * or Start-UP or One year Research in Industry/ Other Academic or Research Institute*	0	0	24	12
3	PE401	Online Course (12 weeks) (GNEL-8)	3	1	0	4
4	PE402	Online Course (12 weeks) (GNEL-9)	3	1	0	4
TOTAL						**23**

SEMESTER VIII

S. No.	Course Code	Course Title	L	T	P	C
1	PE403	DEL-6/ Online Course (12 weeks)	3	0	0	3
2	PE404	DEL-7/ Online Course (12 weeks)	3	0	0	3
3	OE402	GNEL-10 (HSS)/ Online Course (12 weeks)	3	0	0	3
4	OE403	GNEL-11/ Online Course (12 weeks)	3	0	0	3
TOTAL						**12**

Bouquet Department Electives (DEL) 4th Year

Sl. No.	Course	L	T	P	C
1	Communication Engineering	3	0	0	3
2	Power System Optimization	3	0	0	3
3	Multivariable Control	3	0	0	3
4	DSP Based Control of Drives	3	0	0	3
5	Power Systems Protection	3	0	0	3
6	Advanced Electromechanics	3	0	0	3
7	Operating Systems	3	0	0	3
8	Robotics and Automation	3	0	0	3
9	Power Quality	3	0	0	3
10	Machine Intelligence and Learning	3	0	0	3
11	Multicore Systems	3	0	0	3
12	Renewable Energy System	3	0	0	3
13	Digital Control	3	0	0	3
14	Switch Mode Power Conversion	3	0	0	3
15	Power System Dynamics and Control	3	0	0	3
16	Optimal Control Theory	3	0	0	3
17	Digital Image Processing	3	0	0	3
18	Multirate Signal Processing	3	0	0	3
19	Smart Grid Technology	3	0	0	3
20	I.C. Technology	3	0	0	3
21	Power System Analysis and Stability	3	0	0	3
22	Power System Operation and Control	3	0	0	3
23	Industrial Drives	3	0	0	3
24	Sensors and Actuators	3	0	0	3
25	Speech Processing	3	0	0	3
26	Signal Compression	3	0	0	3
27	Computer Networks	3	0	0	3
28	Microwave Engineering	3	0	0	3

Bouquet of HSS/ Management Courses

Sl. No.	Course	L	T	P	C
1	Economics	3	0	0	3
2	Psychology	3	0	0	3
3	Sociology	3	0	0	3
4	Industrial Management	3	0	0	3
5	Organization Behaviour	3	0	0	3

SEMESTER – I

SEMESTER I
Physics- I

Course Code	**:**	**BS101**
Course Title	**:**	**Physics- I**
Number of Credits	**:**	**5 (L: 3, T: 1, P: 2)**
Course Category	**:**	**Basic Science Courses**
Course Contents in Physics (Any One)	**:**	**Anyone from the following options** **i. Introduction to Electromagnetic Theory** **ii. Introduction to Mechanics** **iii. Quantum Mechanics for Engineers** **iv. Oscillation, Waves and Optics** **v. Other Relevant Courses**

Course Objectives: To enhance the fundamental knowledge in Physics and its applications relevant to various streams of Engineering and Technology.

1. Introduction to Electromagnetic Theory
Pre-requisites (if any): Mathematics course with vector calculus

Module I: Electrostatics in vacuum

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 Faraday'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 II: Electrostatics in a linear dielectric medium

Electrostatic field and potential of a dipole. Bound charges due to electric polarisation; 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 III: Magnetostatics

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 IV: Magnetostatics in a linear magnetic medium

Magnetisation and associated bound currents; auxiliary magnetic field H; Boundary conditions on B and 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 V: Faraday's law

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 VI: Displacement current, Magnetic field due to time-dependent electric field and Maxwell's equations

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 quasistatic approximation. Maxwell's equation in vacuum and non-conducting medium; Energy in an electromagnetic field; Flow of energy and Pointing vector with examples. Qualitative discussion of momentum in electromagnetic fields.

Module VII: Electromagnetic waves

The wave equation; Plane electromagnetic waves in vacuum, their transverse nature and polarisation; 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.

Laboratory - Introduction to Electromagnetic Theory

Choice of experiments from the following:

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

Textbooks / References:

1. A.B. Bhattacharya, Engineering Physics
2. David Griffiths, Introduction to Electrodynamics

3. Halliday and Resnick, Physics
4. W. Saslow, Electricity, magnetism and light

Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1	Introduction To Electromagnetic Theory	Prof. Manoj Harbola	IIT Kanpur

Experiments that may be performed through virtual labs:

S. No.	Experiment Name	Experiment Link(s)
1	LC circuit and LCR circuit;	1. http://vlab.amrita.edu/?sub=1&brch=75&sim=326&cnt=1 2. http://vlab.amrita.edu/?sub=1&brch=75&sim=330&cnt=1 3. http://vlab.amrita.edu/?sub=1&brch=75&sim=318&cnt=1 4. http://vlab.amrita.edu/?sub=1&brch=75&sim=325&cnt=1 5. http://vlabs.iitkgp.ernet.in/asnm/exp12/index.htm
2	Resonance phenomena in LCR circuits	http://vlab.amrita.edu/?sub=1&brch=75&sim=325&cnt=1

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2. Introduction to Mechanics
Pre-requisites (if any): High School Education

Module I

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 II

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 III

Non-inertial frames of reference; Rotating coordinate system: Five-term acceleration formula. Centripetal and Coriolis accelerations; Applications: Weather systems, Foucault pendulum;

Module IV

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

Module V

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 VI

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.

Laboratory - Introduction to Mechanics

1. Suggested list of experiments from the following:
2. Coupled oscillators;
3. Experiments on an air-track;
4. Experiment on moment of inertia measurement,
5. Experiments with gyroscope;
6. Resonance phenomena in mechanical oscillators.

Textbooks/References:

1. Engineering Mechanics, 2nd ed. – D.S. Bedi & M.P. Poonia

2. Introduction to Mechanics – A.B. Bhattacharya, Atanu Nag
3. Engineering Mechanics, 2nd ed. — MK Harbola
4. Introduction to Mechanics — MK Verma
5. Basic Mechanical Engineering – M.P. Poonia & S.C. Sharma
6. An Introduction to Mechanics — D Kleppner & R Kolenkow
7. Principles of Mechanics — JL Synge & BA Griffiths
8. Mechanics — JP Den Hartog
9. Engineering Mechanics - Dynamics, 7th ed. - JL Meriam
10. Mechanical Vibrations — JP Den Hartog
11. Theory of Vibrations with Applications — WT Thomson

Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1	Engineering Mechanics	Prof. Manoj Harbola	IIT Kanpur

Experiments that may be performed through virtual labs:

S. No.	Experiment Name	Experiment Link(s)
1	Experiment on moment of inertia measurement.	https://vlab.amrita.edu/?sub=1&brch=74&m=571&cnt=1

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3. Quantum Mechanics for Engineers
Pre-requisites (if any): Mathematics Course on Differential equations & linear algebra

Module I: Wave nature of particles and the Schrodinger equation

Introduction to Quantum mechanics, 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 II: Mathematical Preliminaries for quantum mechanics

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

Module III: Applying the Schrodinger equation

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, fieldionisation 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 IV: Introduction to molecular bonding

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

Module V: Introduction to solids

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.

Laboratory - Quantum Mechanics for Engineers

Suggested list of experiments: Frank-Hertz experiment; photoelectric effect experiment; recording hydrogen atom spectrum.

Textbooks/References:

1. Engineering Physics, A.B. Bhattacharya
2. Eisberg and Resnick, Introduction to Quantum Physics
3. D. J. Griffiths, Quantum mechanics
4. Richard Robinett, Quantum Mechanics
5. Daniel McQuarrie, Quantum Chemistry

Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1	Introduction To Electromagnetic Theory	Prof. Manoj Harbola	IIT Kanpur
2	Quantum Mechanics I	Prof. P. Ramadevi	IIT Bombay

Experiments that may be performed through virtual labs:

S. No.	Experiment Name	Experiment Link(s)
1	Photoelectric effect experiment.	http://mpv-au.vlabs.ac.in/moderphysics/Photo_Electric_Effect/

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4. Oscillation, Waves and Optics
Pre-requisites (if any): Mathematics Course on Differential equations & linear algebra

Module I: Simple harmonic motion, damped and forced simple harmonic oscillator
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 II: Non-dispersive transverse and longitudinal waves in one dimension and introduction to dispersion

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 III: The propagation of light and geometric optics

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 IV: Wave optics

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 V: Lasers

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, CO2), 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.

Laboratory - Oscillations, waves and optics

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.

Textbooks / References:

1. A.B. Bhattacharya, Engineering Physics
2. Ian G. Main, Oscillations and waves in physics
3. H.J. Pain, The physics of vibrations and waves
4. E. Hecht, Optics
5. A. Ghatak, Optics
6. O. Svelto, Principles of Lasers

Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1	Waves And Oscillations	Prof. M. S. Santhanam	IISER Pune

Experiments that may be performed through virtual labs:

S. No.	Experiment Name	Experiment Link(s)
1	Diffraction and interference xperiments (from ordinary light or laser pointers).	http://ov-au.vlabs.ac.in/optics/Diffraction_Grati n g/
2	Minimum deviation from a prism.	http://ov-au.vlabs.ac.in/optics/Spectrometer_i_d _Curve/

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Mathematics- I

Course Code	:	**BS-02**
Course Title	**:**	**Mathematics- I**
Number of Credits	**:**	**4 (L: 3, T: 1, P: 0)**
Course Category	**:**	**Basic Science Courses**

Course Objectives: The goal of this course is to achieve conceptual understanding and to retain the best traditions of traditional calculus. The syllabus is designed to provide the basic tools of calculus mainly for the purpose of modelling the engineering problems mathematically and obtaining solutions. This is a foundation course which mainly deals with topics such as single variable and multivariable calculus and plays an important role in the understanding of science, engineering, economics and computer science, among other disciplines.

Course Contents:

Module 1: Basic Calculus:

Curvature, 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: Single-variable Calculus (Differentiation):

Rolle's Theorem, Mean value theorems and applications; Extreme values of functions; Linear approximation; Indeterminate forms and L'Hospital's rule.

Module 3: Sequences and series:

Limits of sequence of numbers, Calculation of limits, Infinite series; Tests for convergence; Power series, Taylor and Maclaurin series; Taylor theorem, convergence of Taylor series, error estimates.

Module 4: Multivariable Calculus (Differentiation):

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

Module 5: **Multivariable Calculus (Integration):**

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 Gauss and Stokes.

Textbooks / References:

1. Reena Garg, Advanced Engineering Mathematics, Khanna Book Publishing, 2023.

2. Reena Garg, Engineering Mathematics, Khanna Book Publishing, 2023.
3. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Edition, Pearson, Reprint, 2002.
4. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
5. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11th Reprint, 2010.
6. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.
7. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2008.
8. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36th Edition, 2010.

Note: The modules have been prepared keeping the following from the Textbooks/References in mind:

(1) Module 1: The relevant sections from Chapters 2, 6 and 11 of [3].
(2) Module 2: Sections 3.1, 3.2, 3.3, 3.7 & 6.6 of [1].
(3) Module 3: Sections 8.1-8.6, 8.8-8.10 of [1].
(4) Module 4: Sections 12.1-12.5, 12.7-12.9 of [1].
(1) Module 5: Sections 13.1 – 13.7, 14.1 – 14.8 of [1].

Course outcomes: The objective of this course is to familiarise the prospective engineers with techniques in calculus, multivariate differentiation and integration. 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.
- To acquaint the student with mathematical tools needed in evaluating multiple integrals and their usage.

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Basic Electrical Engineering

Course Code	**:**	**ES101**
Course Title	**:**	**Basic Electrical Engineering**
Number of Credits	**:**	**4 (L: 2, T: 1, P: 2)**
Course Category	**:**	**Engineering Science Courses**

Course Objectives: The objective of this Course is to provide the students with an introductory and broad treatment of the field of Electrical Engineering.

Course Contents:

Module I: D. C. Circuits covering, Ohm's Law and Kirchhoff's Laws; Analysis of series, parallel and series-parallel circuits excited by independent voltage sources; Power and energy; Electromagnetism covering, Faradays Laws, Lenz's Law, Fleming's Rules, Statically and dynamically induced EMF; Concepts of self-inductance, mutual inductance and coefficient of coupling; Energy stored in magnetic fields;

Module II: Single Phase A.C. Circuits covering, Generation of sinusoidal voltage- definition of average value, root mean square value, form factor and peak factor of sinusoidal voltage and current and phasor representation of alternating quantities; Analysis with phasor diagrams of R, L, C, RL, RC and RLC circuits; Real power, reactive power, apparent power and power factor, series, parallel and series- parallel circuits; Three Phase A.C. Circuits covering, Necessity and Advantages of three phase systems, Generation of three phase power, definition of Phase sequence, balanced supply and balanced load; Relationship between line and phase values of balanced star and delta connections; Power in balanced three phase circuits, measurement of power by two wattmeter method;

Module III: Transformers covering, Principle of operation and construction of single phase transformers (core and shell types). EMF equation, losses, efficiency and voltage regulation; Synchronous Generators covering, Principle of operation; Types and constructional features; EMF equation;

Module IV: DC Machines covering, working principle of DC machine as a generator and a motor; Types and constructional features; EMF equation of generator, relation between EMF induced and terminal voltage enumerating the brush drop and drop due to armature reaction; DC motor working principle; Back EMF and its significance, torque equation; Types of D.C. motors, characteristics and applications; Necessity of a starter for DC motor;

Module V: Three Phase Induction Motors covering; Concept of rotating magnetic field; Principle of operation, types and constructional features; Slip and its significance; Applications of squirrel cage and slip ring motors; Necessity of a starter, star-delta starter.

Module VI: Sources of Electrical Power covering, Introduction to Wind, Solar, Fuel cell,Tidal, Geo-thermal, Hydroelectric, Thermal-steam, diesel, gas, nuclear power plants; Concept of cogeneration, and distributed generation;

Textbooks / Referencs:

1. Ritu Sahdev (2024), Basic Electrical Engineering, Khanna Book Publishing Co.
2. Nagrath I.J. and D. P. Kothari (2001), Basic Electrical Engineering, Tata McGraw Hill.
3. Hayt and Kimberly, Engineering Circuit Analysis, Tata McGraw Hill.
4. Kulshreshtha D.C. (2009), Basic Electrical Engineering, Tata McGraw Hill.
5. Rajendra Prasad (2009), Fundamentals of Electrical Engineering, Prentice Hall

Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1	Basic Electric Circuits	Prof. Ankush Sharma	IIT Kanpur
2	Basic Electrical Circuits	Prof. Nagendra Krishnapura	IITM
3	Fundamentals Of Electrical Engineering	Prof. Debapriya Das	IIT KGP

Course Outcomes:

The students will learn:

1. To explain strong basics of Electrical Engineering and practical implementation of Electrical fundamentals.
2. To identify different applications of commonly used electrical machinery.

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Engineering Graphics & Design

Course Code	**:**	**ES102**
Course Title	**:**	**Engineering Graphics & Design**
Number of Credits	**:**	**3 (L: 1, T: 0, P: 4)**
Course Category	**:**	**Engineering Science Courses**

Course Objectives:

The objective of this Course is to provide the basic knowledge about Engineering Drawing. Detailed concepts are given in projections, technical drawing, dimensioning and specifications, so useful for a student in preparing for an engineering career.

Course 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 I: Introduction to Engineering Drawing

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 II: Orthographic Projections

Principles of Orthographic Projections-Conventions - Projections of Points and lines inclined to both planes; Projections of planes inclined Planes - Auxiliary Planes;

Module III: 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 IV: Sections and Sectional Views of Right Angular Solids

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 V: Isometric Projections

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 VI: Overview of Computer Graphics

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 VII: Customisation & CAD Drawing

Consisting of set up of the drawing page and the printer, including scale settings, setting up of Modules 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 VIII: 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 customised 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 visualisation exercises. Dimensioning guidelines, tolerancing techniques; dimensioning and scale multi views of dwelling;

Module IX: 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).

Textbooks / Reference Books:

1. Jain, Pradeep, (2024), Engineering Graphics and Design, Khanna Book Publishing Co.
2. Bhatt N.D., Panchal V.M. & Ingle P.R., (2014), Engineering Drawing, Charotar Publishing House.
3. Shah, M.B. & Rana B.C. (2008), Engineering Drawing and Computer Graphics, Pearson Education.
4. Agrawal B. & Agrawal C. M. (2012), Engineering Graphics, TMH Publication
5. Narayana, K.L. & P Kannaiah (2008), Text book on Engineering Drawing, Scitech Publishers.
6. (Corresponding set of) CAD Software Theory and User Manuals.

Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1	Prof. Rajaram Lakkaraju	IIT KGP	Engineering Drawing And Computer Graphics
2	Prof. Nihar Ranjan Patra	IIT Kanpur	Engineering Graphics

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 students will learn:

- To describe engineering design and its place in society.
- To discuss the visual aspects of engineering design.
- To use engineering graphics standards.
- To illustrate solid modelling.
- To use computer-aided geometric design.
- To design creating working drawings.
- To inspect engineering communication.

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English for Technical Writing

Course Code	**:**	**HS101**
Course Title	**:**	**English for Technical Writing**
Number of Credits	**:**	**3 (L: 2, T: 0, P: 2)**
Course Category	**:**	**Humanities & Social Science Course**

Course Objectives:

- To provide learning environment to practice listening, speaking, reading and writing skills.
- To assist the students to carry on the tasks and activities through guided instructions and materials.
- To effectively integrate English language learning with employability skills and training.
- To provide hands-on experience through case-studies, mini-projects, group and individual presentations.

Course Contents:

Module I: 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.

Module II: Basic Writing Skills

1.1. Sentence Structures
1.2. Use of phrases and clauses in sentences
1.3. Importance of proper punctuation
1.4. Creating coherence
1.5. Organizing principles of paragraphs in documents
1.6. Techniques for writing precisely

Module III: Identifying Common Errors in Writing
1.1. Subject-verb agreement
1.2. Noun-pronoun agreement
1.3. Misplaced modifiers
1.4. Articles
1.5. Prepositions
1.6. Redundancies
1.7. Clichés

Module IV: Nature and Style of sensible Writing

1.1. Describing
1.2. Defining
1.3. Classifying
1.4. Providing examples or evidence
1.5. Writing introduction and conclusion

Module V: Writing Practices

1.1. Comprehension
1.2. Précis Writing
1.3. Essay Writing

Module VI: Oral Communication

(This Module 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

Textbooks/References:

1. Communication Skills in English. Anjana Tiwari. Khanna Book Publishing. 2023.
2. Practical English Usage. Michael Swan. OUP. 1995.
3. Remedial English Grammar. F.T. Wood. Macmillan.2007
4. On Writing Well. William Zinsser. Harper Resource Book. 2001
5. Study Writing. Liz Hamp-Lyons and Ben Heasly. Cambridge University Press. 2006.
6. Communication Skills. Sanjay Kumar and PushpLata. Oxford University Press. 2011.
7. Exercises in Spoken English. Parts. I-III. CIEFL, Hyderabad. Oxford University Press.

Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1	English Language For Competitive Exams	Prof. Aysha Iqbal	IIT Madras
2	Technical English For Engineers	Prof. Aysha Iqbal	IITM

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

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Design Thinking

Course Code	**:**	**ES103**
Course Title	**:**	**Design Thinking**
Number of Credits	**:**	**1 (L: 0, T: 0, P: 2)**
Course Category	**:**	**Engineering Science Courses**

Course Objectives:

The objective of this Course is to provide the new ways of creative thinking and Learn the innovation cycle of Design Thinking process for developing innovative products which useful for a student in preparing for an engineering career.

Course Contents:

Unit 1: An Insight to Learning

Understanding the Learning Process, Kolb's Learning Styles, Assessing and Interpreting

Unit 2: Remembering Memory

Understanding the Memory process, Problems in retention, Memory enhancement techniques

Unit 3: Emotions: Experience & Expression

Understanding Emotions: Experience & Expression, Assessing Empathy, Application with Peers

Unit 4: Basics of Design Thinking

Definition of Design Thinking, Need for Design Thinking, Objective of Design Thinking, Concepts & Brainstorming, Stages of Design Thinking Process (explain with examples) – **Empathise, Define, Ideate, Prototype, Test**

Unit 5: Being Ingenious & Fixing Problem

Understanding Creative thinking process, Understanding Problem Solving, Testing Creative Problem Solving

Unit 6: Process of Product Design

Process of Engineering Product Design, Design Thinking Approach, Stages of Product Design, Examples of best product designs and functions, **Assignment – Engineering Product Design**

Unit 7: Prototyping & Testing

What is Prototype? Why Prototype? Rapid Prototype Development process, Testing, **Sample**

Example, Test Group Marketing

Unit 8: Celebrating the Difference

Understanding Individual differences & Uniqueness, Group Discussion and Activities to encourage the understanding, acceptance and appreciation of Individual differences

Unit 9: Design Thinking & Customer Centricity

Practical Examples of Customer Challenges, Use of Design Thinking to Enhance Customer Experience, Parameters of Product experience, Alignment of Customer Expectations with Product Design

Unit 10: Feedback, Re-Design & Re-Create

Feedback loop, Focus on User Experience, Address "ergonomic challenges, User focused design, rapid prototyping & testing, final product, Final Presentation – **"Solving Practical Engineering Problem through Innovative Product Design & Creative Solution".**

Course Outcomes:

Student will able to -

1. Compare and classify the various learning styles and memory techniques and Apply them in their engineering education
2. Analyze emotional experience and Inspect emotional expressions to better understand users while designing innovative products
3. Develop new ways of creative thinking and Learn the innovation cycle of Design Thinking process for developing innovative products
4. Propose real-time innovative engineering product designs and Choose appropriate frameworks, strategies, techniques during prototype development
5. Perceive individual differences and its impact on everyday decisions and further Create a better customer experience

Textbooks/References:

1. Developing Thinking Skills. E. Balaguruswamy. 2023.

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IDEA Lab Workshop

Course Code	**:**	**AU-01**
Course Title	**:**	**IDEA Lab Workshop**
Number of Credits	**:**	**0 (L: 2, T: 0, P: 4)**
Course Category	**:**	**AU-101**
Prerequisites	**:**	**None**

Course Objectives:

1. To learn all the skills associated with the tools and inventory associated with the IDEA Lab.
2. Learn useful mechanical and electronic fabrication processes.
3. Learn necessary skills to build useful and standalone system/ project with enclosures.
4. Learn necessary skills to create print and electronic documentation for the system/project

Course Contents*:*

Module	Topics	
1	Electronic component familiarisation, Understanding electronic system design flow. Schematic design and PCB layout and Gerber creation using EagleCAD. Documentation using Doxygen, Google Docs, Overleaf. Version control tools - GIT and GitHub. Basic 2D and 3D designing using CAD tools such as FreeCAD, Sketchup, Prusa Slicer, FlatCAM, Inkspace, OpenBSP and VeriCUT.	Introduction to basic hand tools - Tape measure, combination square, Vernier calliper, hammers, fasteners, wrenches, pliers, saws, tube cutter, chisels, vice and clamps, tapping and threading. Adhesives Introduction to Power tools: Power saws, band saw, jigsaw, angle grinder, belt sander, bench grinder, rotary tools. Various types of drill bits,

2	Familiarisation and use of basic measurement instruments - DSO including various triggering modes, DSO probes, DMM, LCR bridge, Signal and function generator. Logic analyzer and MSO. Bench power supply (with 4-wire output) Circuit prototyping using (a) breadboard, (b) Zero PCB (c) 'Manhattan' style and (d) custom PCB. Single, double and multilayer PCBs. Single and double-sided PCB prototype fabrication in the lab. Soldering using soldering iron/station. Soldering using a temperature controlled reflow oven. Automated circuit assembly and soldering using pick and place machines.	Mechanical cutting processes - 3-axis CNC routing, basic turning, milling, drilling and grinding operations, Laser cutting, Laser engraving etc. Basic welding and brazing and other joining techniques for assembly. Concept of Lab aboard a Box.
3	Electronic circuit building blocks including common sensors. Arduino and Raspberry Pi programming and use. Digital Input and output. Measuring time and events. PWM. Serial communication. Analog input. Interrupts programming. Power Supply design (Linear and Switching types), Wireless power supply, USB PD, Solar panels, Battery types and charging	3D printing and prototyping technology – 3D printing using FDM, SLS and SLA. Basics of 3D scanning, point cloud data generation for reverse engineering. Prototyping using subtractive cutting processes. 2D and 3D Structures for prototype building using Laser cutter and CNC routers. Basics of IPR and patents; Accessing and utilizing patent information in IDEA Lab
4	Discussion and implementation of a mini project.	
5	Documentation of the mini project (Report and video).	

Laboratory Activities:

S. No.	List of Lab activities and experiments
1.	Schematic and PCB layout design of a suitable circuit, fabrication and testi of the circuit.
2.	Machining of 3D geometry on soft material such as soft wood or modelling w
3.	3D scanning of computer mouse geometry surface. 3D printing of scann geometry using FDM or SLA printer.
4.	2D profile cutting of press fit box/casing in acrylic (3 or 6 m thickness)/cardboard, MDF (2 mm) board using laser cutter & engraver.
5.	2D profile cutting on plywood /MDF (6-12 mm) for press fit designs.
6.	Familiarity and use of welding equipment.
7.	Familiarity and use of normal and wood lathe.
8.	Embedded programming using Arduino and/or Raspberry Pi.
9.	Design and implementation of a capstone project involving embedded hardwa software and machined or 3D printed enclosure.

Reference Books:

S. No.	Title
1.	AICTE's Prescribed Textbook: Workshop / Manufacturing Practices (with Lab Manual), Khanna Book Publishing, New Delhi.
2.	All-in-One Electronics Simplified, A.K. Maini; 2021. ISBN-13: 978-9386173393, Khanna Book Publishing Company, New Delhi.
3.	Simplified Q&A - Data Science with Artificial Intelligence, Machine Learning and Deep Learning, Rajiv Chopra, ISBN: 978-9355380821, Khanna Book Publishing Company, New Delhi.
4.	3D Printing & Design, Dr. Sabrie Soloman, ISBN: 978-9386173768, Khanna Book Publishing Company, New Delhi.

5.	The Big Book of Maker Skills: Tools & Techniques for Building Great Tech Projects. Chris Hackett. Weldon Owen; 2018. ISBN-13: 978-1681884325.
6.	The Total Inventors Manual (Popular Science): Transform Your Idea into a Top-Selling Product. Sean Michael Ragan (Author). Weldon Owen; 2017. ISBN-13: 978-1681881584.
7.	Make: Tools: How They Work and How to Use Them. Platt, Charles. Shroff/Maker Media. 2018. ISBN-13: 978-9352137374
8.	The Art of Electronics. 3rd edition. Paul Horowitz and Winfield Hill. Cambridge University Press. ISBN: 9780521809269
9.	Practical Electronics for Inventors. 4th edition. Paul Sherz and Simon Monk. McGraw Hill. ISBN-13: 978-1259587542
10.	Encyclopedia of Electronic Components (Volume 1, 2 and 3). Charles Platt. Shroff Publishers. ISBN-13: 978-9352131945,978-9352131952, 978-9352133703
11.	Building Scientific Apparatus. 4th edition. John H. Moore, Christopher C. Davis, Michael A. Coplan and Sandra C. Greer. Cambridge University Press. ISBN-13: 978-0521878586
12.	Programming Arduino: Getting Started with Sketches. 2nd edition. Simon Monk. McGraw Hill. ISBN-13: 978-1259641633
13.	Make Your Own PCBs with EAGLE: From Schematic Designs to Finished Boards. Simon Monk and Duncan Amos. McGraw Hill Education. ISBN-13 : 978-1260019193.
14.	Pro GIT. 2nd edition. Scott Chacon and Ben Straub. A press. ISBN-13 : 978- 1484200773
15.	Venuvinod, PK., MA. W., Rapid Prototyping – Laser Based and Other Technologies, Kluwer, 2004.
16.	Ian Gibson, David W Rosen, Brent Stucker., “Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing”, Springer, 2010
17.	Chapman W.A.J, “Workshop Technology”, Volume I, II, III, CBS Publishers and distributors, 5th Edition,2002.

SEMESTER – II

SEMESTER II

Chemistry

Course Code	**:**	**BS-03**
Course Title	**:**	**Chemistry**
Number of Credits	**:**	**4 (L: 3 , T: 0, P: 2)**
Course Category	**:**	**Basic Science Course**
Prerequisites	**:**	**None**

Course Objectives:

The objective of the Chemistry I is to acquaint the students with the basic phenomenon/concepts of chemistry, the student faces during course of their study in the industry and Engineering field. The student with the knowledge of the basic chemistry, will understand and explain scientifically the various chemistry related problems in the industry/engineering field. The student will able to understand the new developments and breakthroughs efficiently in engineering and technology. The introduction of the latest (R&D oriented) topics will make the engineering student upgraded with the new technologies.

Course Contents:

Module I: Atomic and Molecular Structure

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 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.

Module II: Spectroscopic techniques and applications

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.

Module III: Intermolecular forces and potential energy surfaces

Ionic, dipolar and van Der Waals interactions. Equations of state of real gases and critical phenomena. Potential energy surfaces of H3, H2F and HCN and trajectories on these surfaces.

Module IV: Use of free energy in chemical equilibria

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 V: Periodic properties

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, ionisation energies, electron affinity and electronegativity, polarizability, oxidation states, coordination numbers and geometries, hard soft acids and bases, molecular geometries.

Module VI: Stereochemistry

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 VII: Organic reactions and synthesis of a drug molecule

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

Practical Class Program: 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.

Textbooks / Reference Books:

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

Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1	Chemistry - I	Prof. Mangala Sunder Krishnan	IITM

Experiments that may be performed through virtual labs:

S. No.	Experiment Name	Experiment Link(s)
1	Determination of surface tension and viscosity.	http://pcv-au.vlabs.ac.in/physical-chemistry/Determination_of_Viscosity_of_Organic_Solvents/
2	Ion exchange column for removal of hardness of water.	http://icv-au.vlabs.ac.in/inorganic-chemistry/Water_Analysis_Determination_of_Chemical_Parameters/
3	Determination of chloride content of water.	http://vlabs.iitb.ac.in/vlabs-dev/labs/nitk_labs/Environmental_Engineering_1/experiments/determination-of-chloride-nitk/simulation.html
4	Colligative properties using freezing point depression.	http://pcv-au.vlabs.ac.in/physical-chemistry/Cryoscopy/

5	Determination of the rate constant of a reaction.	http://pcv-au.vlabs.ac.in/physical-chemistry/EMF_Measurement/
6	Determination of cell constant and conductance of solutions.	http://icv-au.vlabs.ac.in/inorganic-chemistry/Water_Analysis_Determination_of_Physical_Parameters/
7	Potentiometrydetermination of redox potentials and emfs.	http://pcv-au.vlabs.ac.in/physical-chemistry/EMF_Measurement/
8	Saponification/acid value of an oil.	http://biotech01.vlabs.ac.in/bio-chemistry/Estimation_of_Saponification_Value_of_Fats_or_Oils/
9	Lattice structures and packing of spheres.	https://vlab.amrita.edu/?sub=1&brch=282 &sim=370&cnt=1

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 nanometre levels, one has to base the description of all chemical processes at molecular levels. The course will enable the students:

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

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.
- To measure molecular/system properties such as surface tension, viscosity, conductance of solutions, redox potentials, chloride content of water, etc.
- To synthesise a small drug molecule and analyze a salt sample.

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Mathematics-II

Course Code	**:**	**BS-04**
Course Title	**:**	**Mathematics-II**
Number of Credits	**:**	**4 (L: 3 , T: 1, P: 0)**
Course Category	**:**	**Basic Science Course**
Prerequisites	**:**	**None**

Course Objectives:

Mathematics fundamental necessary to formulate, solve and analyze engineering problems.

Course Contents:

Module 1: Matrices

Linear Systems of Equations; Linear Independence; Rank of a Matrix; Determinant, Inverse of a matrix, rank-nullity theorem; System of linear equations; Symmetric, skew-symmetric and orthogonal matrices; Determinants; Eigenvalues and eigenvectors; Orthogonal transformation; Diagonalisation of matrices; Cayley-Hamilton Theorem.

Module 2: First order ordinary differential equations:

Exact, linear and Bernoulli'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:

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

Module 4: Complex Variable – Differentiation:

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:

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. Reena Garg, Engineering Mathematics, Khanna Book Publishing, 2023.
2. Reena Garg, Advanced Engineering Mathematics, Khanna Book Publishing, 2023.
3. Erwin Kreyszig, Advanced Engineering Mathematics, 10th Edition, John Wiley & Sons, 2006.
4. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.
5. W. E. Boyce and R. C. DiPrima, Elementary Differential Equations and Boundary Value Problems, 9th Edn., Wiley India, 2009.
6. D. Poole, Linear Algebra: A Modern Introduction, 2nd Edition, Brooks/Cole, 2005.
7. S. L. Ross, Differential Equations, 3rd Ed., Wiley India, 1984.
8. E. A. Coddington, An Introduction to Ordinary Differential Equations, Prentice Hall India, 1995.
9. E. L. Ince, Ordinary Differential Equations, Dover Publications, 1958.
10. J. W. Brown and R. V. Churchill, Complex Variables and Applications, 7th Ed., Mc-Graw Hill, 2004.
11. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2008.
12. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36th Edition, 2010.

Note: The modules have been prepared keeping the following from the Textbooks/References in mind:

(1) Module 1: Sections 7.3-7.5, 7.7, 7.8, 8.1-8.4 of [1].
(2) Module 2: Sections 1.4, 1.5 of [1]; Section 5.1 of [2].
(3) Module 3: Sections 2.5, 2.6, 2.10, 5.1, 5.3, 5.4, 5.5 of [1].
(4) Module 4: Sections 13.3 – 13.7, 17.1 – 17.3 of [1].
(5) Module 5: Sections 14.1 – 14.4, 15.2 – 15.4, 16.1 – 16.4 of [1].

Course Outcomes:

The objective of this course is to familiarise the prospective engineers with techniques in matrices, ordinary 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 essential tool of matrices and linear algebra in a comprehensive manner.
- 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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Programming for Problem Solving

Course Code	**:**	**ES-04**
Course Title	**:**	**Programming for Problem Solving**
Number of Credits	**:**	**4 (L: 2 , T: 1, P: 4)**
Course Category	**:**	**Engineering Science Courses**
Prerequisites	**:**	**None**

Course Objectives:

1. To learn the fundamentals of computers.
2. To understand the various steps in program development.
3. To learn the syntax and semantics of C programming language.
4. To learn the usage of structured programming approach in solving problems.
5. To understated and formulate algorithm for programming script
6. To analyze the output based on the given input variables

Course Contents:

Module I: Introduction to Programming**;** Introduction to components of a computer system (disks, memory, processor, where a program is stored and executed, operating system, compilers etc.)

Idea of Algorithm: steps to solve logical and numerical problems. Representation of Algorithm: Flowchart/Pseudocode with examples.

From algorithms to programs; source code, variables (with data types) variables and memory locations, Syntax and Logical Errors in compilation, object and executable code.

Module II: Arithmetic expressions and precedence.

Module III: Conditional Branching and Loops. Writing and evaluation of conditionals and consequent branching. Iteration and loops.

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

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

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

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

Module VIII: Structures, Defining structures and Array of Structures

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

Module X: File handling (only if time is available, otherwise should be done as part of the lab).

Practical Class Program:

1. Familiarisation with programming environment
2. Simple computational problems using arithmetic expressions
3. Problems involving if-then-else structures
4. Iterative problems e.g., sum of series
5. 1D Array manipulation
6. Matrix problems, String operations
7. Simple functions
8. Programming for solving Numerical methods problems
9. Recursive functions
10. Pointers and structures
11. File operations

Textbooks / References:

1. R.S. Salaria, Programming for Problem Solving, Khanna Book Publishing Co.
2. Byron Gottfried, Schaum's Outline of Programming with C, McGraw-Hill.
3. E. Balaguruswamy, Programming in ANSI C, Tata McGraw-Hill.
4. Brian W. Kernighan and Dennis M. Ritchie, The C Programming Language, Prentice Hall of India.

Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1	Introduction to Programming in C	Prof. Satyadev Nandakumar	IITK
2	Problem solving through Programming in C	Prof. Anupam Basu	IIT KGP

Experiments that may be performed through virtual labs:

S. No.	Experiment Name	Experiment Link(s)
1	Simple computational problems using arithmetic expressions.	http://ps-iiith.vlabs.ac.in/exp7/Introduction.html?domain=Computer%20Science&lab=Problem%20Solving%20Lab
2	Iterative problems e.g., sum of series.	http://ps-iiith.vlabs.ac.in/exp4/Introduction.html?domain=Computer%20Science&lab=Problem%20Solving%20Lab

3	1D Array manipulation.	http://cse02-iiith.vlabs.ac.in/exp4/index.html
4	Matrix problems, String operations.	http://ps-iiith.vlabs.ac.in/exp5/Introduction.html?domain=Computer%20Science&lab=Problem%20Solving%20Lab
5	Simple functions.	http://cse02-iiith.vlabs.ac.in/exp2/index.html
6	Programming for solving Numerical methods problems.	http://ps-iiith.vlabs.ac.in/exp1/Introduction.html?domain=Computer%20Science&lab=Problem%20Solving%20Lab
7	Recursive functions.	http://ps-iiith.vlabs.ac.in/exp6/Introduction.html?domain=Computer%20Science&lab=Problem%20Solving%20Lab

Course Outcomes:

The student will learn following through lectures:

- 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 synthesise 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.

The student will learn following through Practicals:

- 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.

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Biology for Engineers

Course Code	**:**	**BS-05**
Course Title	**:**	**Biology for Engineers**
Number of Credits	**:**	**3 (L: 3 , T: 0, P: 0)**
Course Category	**:**	**BS-04**
Prerequisites	**:**	**None**

Module 1. *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 scientificinquiry.

Module 2. *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, Cerevisiae, D. Melanogaster. elegance, A. Thaliana, M. musculus

Module 3. *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. *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. *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 catalyze 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*

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. DICOM Image formats, The DNA Technology (Use and Application) Regulation Bill, 2019.

Module 7. *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. *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. *Microbiology*

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

Textbooks / References:

1) General Biology, Uma Devi Koduru, Khanna Book Publishing, 2022.

2) 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
3) Outlines of Biochemistry, Conn, E.E; Stumpf, P.K; Bruening, G; Doi, R.H., John Wiley and Sons
4) Principles of Biochemistry (V Edition), By Nelson, D. L.; and Cox, M. M.W.H. Freeman and Company
5) Molecular Genetics (Second edition), Stent, G. S.; and Calender, R.W.H. Freeman and company, Distributed by Satish Kumar Jain for CBS Publisher
6) 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.

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Workshop/Manufacturing Practices

Course Code	**:**	**ES-05**
Course Title	**:**	**Workshop/Manufacturing Practices**
Number of Credits	**:**	**2 (L: 0, T: 0, P: 4)**
Course Category	**:**	**ES-05**
Prerequisites	**:**	**None**

Course Objectives:

1. To provide exposure to the students with hands on experience on various basic engineering practices in Civil, Mechanical, Electrical and Electronics Engineering.
2. To have a study and hands-on-exercise on plumbing and carpentry components.
3. To have a practice on gas welding, foundry operations and fitting
4. To have a study on measurement of electrical quantities, energy and resistance to earth.
5. To have a practice on soldering.

Course Content:

Module I: Manufacturing Methods- casting, forming, machining, joining, advanced manufacturing methods.

Module II: CNC machining, Additive manufacturing.

Module III: Fitting operations & power tools.

Module IV: Electrical & Electronics.

Module V: Carpentry.

Module VI: Plastic moulding, glass cutting.

Module VII: Metal casting.

Module VIII: Welding (arc welding & gas welding), brazing.

Practicals:

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

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

Textbooks /References:

1. D.K. Veerana, Workshop/ Manufacturing Practices, Khanna Book Publishing, 2023.
2. 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**.**
3. Kalpakjian S. And Steven S. Schmid, "Manufacturing Engineering and Technology", 4th edition, Pearson Education India Edition, 2002.
4. Gowri P. Hariharan and A. Suresh Babu," Manufacturing Technology – I" Pearson Education, 2008.
5. Roy A. Lindberg, "Processes and Materials of Manufacture", 4th edition, Prentice Hall India, 1998.
6. Rao P.N., "Manufacturing Technology", Vol. I and Vol. II, Tata McGraw Hill House, 2017.

Experiments that may be performed through virtual labs:

S. No.	Experiment Name	Experiment Link(s)
1	Welding shop (Arc welding + Gas welding).	http://mm-coep.vlabs.ac.in/LaserSpotWelding/Theory.html?domain=Mechanical%20Engineering&lab=Welcome%20to%20Micromachining%20laboratory
2	Casting	http://fab-coep.vlabs.ac.in/exp7/Theory.html?domain=Mechanical%20Engineering&lab=Welcome%20to%20FAB%20laboratory

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.

Laboratory Outcomes:

Upon completion of this laboratory course, students will be able:

- To fabricate components with their own hands.
- To relate practical knowledge of the dimensional accuracies and dimensional tolerances possible with different manufacturing processes.
- To design small devices of their interest by assembling different components

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Universal Human Values

Course Code	**:**	**HSM-02**
Course Title	**:**	**Universal Human Values**
Number of Credits	**:**	**3 (L: 2, T: 1, P: 0)**
Course Category	**:**	**HSM-02**
Prerequisites	**:**	**None**

Pre-requisites: None. Universal Human Values 1 (Desirable)

Courses on Human Values

During the Induction Program, students would get an initial exposure to human values through Universal Human Values-I. This exposure is to be augmented by this compulsory full semester foundation course.

Objectives of UHV-II Course

This introductory course input is intended:

1. To help the students appreciate the essential complementarily between 'VALUES' and 'SKILLS' to ensure sustained happiness and prosperity which are the core aspirations of all human beings.
2. To facilitate the development of a Holistic perspective among students towards life and profession as well as towards happiness and prosperity based on a correct understanding of the Human reality and the rest of existence. Such a holistic perspective forms the basis of Universal Human Values and movement towards value-based living in a natural way.
3. To highlight plausible implications of such a Holistic understanding in terms of ethical human conduct, trustful and mutually fulfilling human behavior and mutually enriching interaction with Nature.

   Thus, this course is intended to provide a much-needed orientational input in value education to the young enquiring minds.

Salient Features of the Course

The salient features of this course are:

1. It presents a universal approach to value education by developing the right understanding of reality (i.e. a worldview of the reality “as it is”) through the process of self-exploration.
2. The whole course is presented in the form of a dialogue whereby a set of proposals about various aspects of the reality are presented and the students are encouraged to self-explore the proposals by verifying them on the basis of their natural acceptance within oneself and validate experientially in living.
3. The prime focus throughout the course is toward affecting a qualitative transformation in the life of the student rather than just a transfer of information.
4. While introducing the holistic worldview and its implications, a critical appraisal

of the prevailing notions is also made to enable the students discern the difference on their own right.

Course Methodology

1. The methodology of this course is explorational and thus universally adaptable. It involves a systematic and rational study of the human being vis-à-vis the rest of existence.
2. The course is in the form of 28 lectures (discussions) and 14 practice sessions.
3. It is free from any dogma or value prescriptions.
4. It is a process of self-investigation and self-exploration, and not of giving sermons. Whatever is found as truth or reality is stated as a proposal and the students are facilitated to verify it in their own right, based on their Natural Acceptance and subsequent Experiential Validation – the whole existence is the lab and every activity is a source of reflection.
5. This process of self-exploration takes the form of a dialogue between the teacher and the students to begin with, and then to continue within the student in every activity, leading to continuous self-evolution.
6. This self-exploration also enables them to critically evaluate their pre-conditionings and present beliefs.

Course Contents:

The course has 28 lectures and 14 tutorials in 5 modules. The lectures and tutorials are of 01- hour duration. Tutorial sessions are to be used to explore and practice what has been proposed during the lecture sessions.

The Teacher's Manual provides the outline for lectures as well as practice sessions. The teacher is expected to present the issues to be discussed as propositions and encourage the students to have a dialogue.

The syllabus for the lectures and practice sessions is given below:

Module 1 – Introduction to Value Education (6 lectures and 3 tutorials for practice session)

Lecture 1: Right Understanding, Relationship and Physical Facility (Holistic Development and the Role of Education)

Lecture 2: Understanding Value Education

Tutorial 1: **Practice Session PS1** Sharing about Oneself

Lecture 3: Self-exploration as the Process for Value Education

Lecture 4: Continuous Happiness and Prosperity – the Basic Human Aspirations

Tutorial 2: Practice Session PS2 Exploring Human Consciousness

Lecture 5: Happiness and Prosperity – Current Scenario

Lecture 6: Method to Fulfill the Basic Human Aspirations

Tutorial 3: Practice Session PS3 Exploring Natural Acceptance

Expected outcome:

The students start exploring themselves: get comfortable with each other and with the teacher; they start appreciating the need and relevance for the course.

The students start finding that technical education without study of human values can generate more problems than solutions. They also start feeling that lack of understanding of human values is the root cause of most of the present-day problems; and a sustained solution could emerge only through understanding of value-based living. Any solution brought out through fear, temptation of dogma will not be sustainable.

The students are able to see that verification on the basic of natural acceptance and experiential validation through living is the only way to verify right or wrong, and referring to any external source like text or instrument or any other person cannot enable them to verify with authenticity; it will only develop assumptions.

The students are able to see that their practice in living is not in harmony with their natural acceptance most of the time, and all they need to do is to refer to their natural acceptance to overcome this disharmony.

The students are able to see that lack of right understanding leading to lack of relationship is the major cause of problems in their family and not the lack of physical facility in most of the cases, while they have given higher priority to earning of physical facility in their life giving less value to or even ignoring relationships and not being aware that right understanding is the most important requirement for any human being.

Module 2 – Harmony in the Human Being (6 lectures and 3 tutorials for practice session) Lecture 7: Understanding Human being as the Co-existence of the Self and the Body **Lecture 8:** Distinguishing between the Needs of the Self and the Body

Tutorial 4: Practice Session PS4 Exploring the difference of Needs of Self and Body

Lecture 9: The Body as an Instrument of the Self

Lecture 10: Understanding Harmony in the Self

Tutorial 5: Practice Session PS5 Exploring Sources of Imagination in the Self

Lecture 11: Harmony of the Self with the Body

Lecture 12: Programme to ensure self-regulation and Health

Tutorial 6: Practice Session PS6 Exploring Harmony of Self with the Body

Expected outcome:

The students are able to see that they can enlist their desires and the desires are not vague. Also they are able to relate their desires to 'I' and 'Body' distinctly. If any desire appears related to both, they are able to see that the feeling is related to I while the physical facility is related to the body. They are also able to see that 'I' and Body are two realities, and most of their desires are related to 'I' and not body, while their efforts are mostly centered on the fulfilment of the needs of the body assuming that it will meet the needs of 'I' too.

The students are able to see that all physical facility they are required for a limited time in a limited quantity. Also, they are able to see that in case of feelings, they want continuity of the naturally acceptable feelings and they do not want feelings which are not naturally acceptable even for a single moment.

The students are able to see that activities like understanding, desire, though and selection are the activities of 'I' only the activities like breathing, palpitation of different parts of the body are fully the activities of the body with the acceptance of 'I' while the activities they do with their sense organs like hearing through ears, seeing through eyes, sensing through touch, tasting through tongue and smelling through nose or the activities they do with their work organs like hands, legs etc. are such activities that require the participation of both 'I' and body.

The students become aware of their activities of 'I' and start finding their focus of attention at different moments. Also they are able to see that most of their desires are coming from outside (through preconditioning or sensation) and are not based on their natural acceptance

The students are able to list down activities related to proper upkeep of the body and practice them in their daily routine. They are also able to appreciate the plants wildly growing in and around the campus which can be beneficial in curing different diseases.

Module 3 – Harmony in the Family and Society (6 lectures and 3 tutorials for practice session)

Lecture 13: Harmony in the Family – the Basic Unit of Human Interaction

Lecture 14: 'Trust' – the Foundational Value in Relationship
Tutorial 7: Practice Session PS7 Exploring the Feeling of Trust
Lecture 15: 'Respect' – as the Right Evaluation

Tutorial 8: Practice Session PS8 Exploring the Feeling of Respect

Lecture 16: Other Feelings, Justice in Human-to-Human Relationship

Lecture 17: Understanding Harmony in the Society

Lecture 18: Vision for the Universal Human Order

Tutorial 9: Practice Session PS9: Exploring Systems to fulfil Human Goal

Expected outcome:

The students are able to note that the natural acceptance (intention) is always for living in harmony, only competence is lacking! We generally evaluate ourselves on the basis of our intention and others on the basis of their competence! We seldom look at our competence and others' intention as a result we conclude that I am a good person and other is a bad person.

The students are able to see that respect is right evaluation, and only right evaluation leads to fulfilment in relationship. Many present problems in the society are an outcome of differentiation (lack of understanding of respect), like gender biasness, generation gap, caste conflicts, class struggle, dominations through power play, communal violence, clash of isms and so on so forth. All these problems can be solved by realizing that the other is like me as he has the same natural acceptance, potential and program to ensure a happy and prosperous life for them and for others through he may have different body, physical facility or beliefs.

The students are able to use their creativity for education children. The students are able to see that they can play a role in providing value education for children. They are able to put in simple words the issues that are essential to understand for children and comprehensible to them. The students are able to develop an outline of holistic model for social science and compare it with the existing model.

Module 4 – Harmony in the Nature/Existence (4 lectures and 2 tutorials for practice session)

Lecture 19: Understanding Harmony in the Nature

Lecture 20: Interconnectedness, self-regulation and Mutual Fulfilment among the Four Orders of Nature

Tutorial 10: Practice Session PS10 Exploring the Four Orders of Nature

Lecture 21: Realizing Existence as Co-existence at All Levels

Lecture 22: The Holistic Perception of Harmony in Existence

Tutorial 11: Practice Session PS11 Exploring Co-existence in Existence

Expected outcome:

The students are able to differentiate between the characteristics and activities of different orders and study the mutual fulfilment among them. They are also able to see that human being s are not fulfilling to other orders today and need to take appropriate

steps to ensure right participation (in terms of nurturing, protection and right utilisation) in the nature.

The students feel confident that they can understand the whole existence; nothing is a mystery in this existence. They are also able to see the interconnectedness in the nature, and point out how different courses of study relate to the different units and levels. Also, they are able to make out how these courses can be made appropriate and holistic.

Module 5 – Implications of the Holistic Understanding – a Look at Professional Ethics (6 lectures and 3 tutorials for practice session)

Lecture 23: Natural Acceptance of Human Values

Lecture 24: Definitiveness of (Ethical) Human Conduct

Tutorial 12: Practice Session PS12 Exploring Ethical Human Conduct

Lecture 25: A Basis for Humanistic Education, Humanistic Constitution and Universal Human Order

Lecture 26: Competence in Professional Ethics

Tutorial 13: Practice Session PS13 Exploring Humanistic Models in Education

Lecture 27: Holistic Technologies, Production Systems and Management Models-Typical Case Studies

Lecture 28: Strategies for Transition towards Value-based Life and Profession

Tutorial 14: Practice Session PS14 Exploring Steps of Transition towards Universal Human Order

Expected outcome:

The students are able to present sustainable solutions to the problems in society and nature. They are also able to see that these solutions are practicable and draw roadmaps to achieve them.

The students are able to grasp the right utilisation of their knowledge in their streams of Technology/Engineering/Management/any other area of study to ensure mutual fulfilment.

E.g. mutually enriching production system with rest of nature.

The students are able to sincerely evaluate the course and share with their friends. They are also able to suggest measures to make the course more effective and relevant. They are also able to make use of their understanding in the course for the happy and prosperous family and society.

Guidelines and Content for Practice Sessions (Tutorials)

In order to connect the content of the proposals with practice (living), 14 practice sessions have been designed. The full set of practice sessions is available in the Teacher's Manual as well as the website.

Practice Sessions for Module 1 – Introduction to Value Education PS1 Sharing about Oneself

PS2 Exploring Human Consciousness PS3 Exploring Natural Acceptance

Practice Sessions for Module 2 – Harmony in the Human Being PS4 Exploring the difference of Needs of Self and Body

PS5 Exploring Sources of Imagination in the Self PS6 Exploring Harmony of Self with the Body

Practice Sessions for Module 3 – Harmony in the Family and Society PS7 Exploring the Feeling of Trust

PS8 Exploring the Feeling of Respect PS9 Exploring Systems to fulfil Human Goal

Practice Sessions for Module 4 – Harmony in the Nature (Existence) PS10 Exploring the Four Orders of Nature PS11 Exploring Co-existence in Existence

Practice Sessions for Module 5 – Implications of the Holistic Understanding – a Look at Professional Ethics

PS12 Exploring Ethical Human Conduct

PS13 Exploring Humanistic Models in Education

PS14 Exploring Steps of Transition towards Universal Human Order

As an example, PS 7 is a practice session in module 3 regarding trust. It is explained below:

PS 7: Form small groups in the class and in that group initiate dialogue and ask the eight questions related to trust. The eight questions are:

1a. Do I want to make myself happy? 1b. Am I able to make myself always happy?

2a. Do I want to make the other happy? 2b. Am I able to make the other always happy?

3a. Does the other want to make him happy? 3b. Is the other able to make him always happy?

4a. Does the other want to make me happy? 4b. Is the other able to make me always happy?

Intention (Natural Acceptance) What is the answer? Competence What is the answer?

Let each student answer the questions for himself/herself and everyone else. Discuss the difference between intention and competence. Observe whether you evaluate your intention and competence as well as the others' intention and competence.

Expected outcome of PS 7: The students are able to see that the first four questions are related to our Natural Acceptance i.e. intention and the next four to our Competence. They are able to note that the intention is always correct, only competence is lacking! We generally evaluate ourselves on the basis of our intention and others on the basis of their competence! We seldom look at our competence and others' intention, as a result we conclude that I am a good person and other is a bad person.

Readings:

1.1 Text Book and Teachers Manual

a. The Textbook

A Foundation Course in Human Values and Professional Ethics, R R Gaur, R Asthana, G P Bagaria, 2nd Revised Edition, Excel Books, New Delhi, 2019. ISBN 978-93-87034-47-1

b. The Teacher's Manual

Teachers' Manual for A Foundation Course in Human Values and Professional Ethics, R R Gaur, R Asthana, G P Bagaria, 2nd Revised Edition, Excel Books, New Delhi, 2019. ISBN 978-93-87034-53-

c. Professional Ethics and Human Values, Premvir Kapoor, ISBN: 978-93-86173-652, Khanna Book Publishing Company, New Delhi, 2022.

Reference Books

1. JeevanVidya: EkParichaya, A Nagaraj, JeevanVidyaPrakashan, Amarkantak, 1999.
2. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
3. The Story of Stuff (Book).
4. The Story of My Experiments with Truth - by Mohandas Karamchand Gandhi
5. Small is Beautiful - E. F Schumacher.
6. Slow is Beautiful - Cecile Andrews
7. Economy of Permanence - J C Kumarappa
8. Bharat Mein Angreji Raj – Pandit Sunderlal
9. Rediscovering India - by Dharampal
10. Hind Swaraj or Indian Home Rule - by Mohandas K. Gandhi
11. India Wins Freedom - Maulana Abdul Kalam Azad
12. Vivekananda - Romain Rolland (English)

13. Gandhi - Romain Rolland (English)

Mode of Conduct (L-T-P-C 2-1-0-3)

Lecture hours are to be used for interactive discussion, placing the proposals about the topics at hand and motivating students to reflect, explore and verify them.

Tutorial hours are to be used for practice sessions.

While analysing and discussing the topic, the faculty mentor's role is in pointing to essential elements to help in sorting them out from the surface elements. In other words, help the students explore the important or critical elements.

In the discussions, particularly during practice sessions (tutorials), the mentor encourages the student to connect with one's own self and do self-observation, self-reflection and self- exploration.

Scenarios may be used to initiate discussion. The student is encouraged to take up" ordinary" situations rather than" extra-ordinary" situations. Such observations and their analyses are shared and discussed with other students and faculty mentor, in a group sitting.

Tutorials (experiments or practical) are important for the course. The difference is that the laboratory is everyday life, and practical are how you behave and work in real life. Depending on the nature of topics, worksheets, home assignment and/or activity are included. The practice sessions (tutorials) would also provide support to a student in performing actions commensurate to his/her beliefs. It is intended that this would lead to development of commitment, namely behaving and working based on basic human values. It is recommended that this content be placed before the student as it is, in the form of a basic foundation course, without including anything else or excluding any part of this content. Additional content may be offered in separate, higher courses.

This course is to be taught by faculty from every teaching department.

Teacher preparation with a minimum exposure to at least one 8-day Faculty Development Program on Universal Human Values is deemed essential.

Suggested Assessment:

This is a compulsory credit course. The assessment is to provide a fair state of development of the student, so participation in classroom discussions, self-assessment, peer assessment etc. will be used in evaluation.

Example:

Assessment by faculty mentor: 10 marks Self-assessment: 10 marks

Assessment by peers: 10 marks

Socially relevant project/Group Activities/Assignments: 20 marks Semester End Examination: 50 marks

The overall pass percentage is 40%. In case the student fails, he/she must repeat the course.

Course Outcome:

By the end of the course, students are expected to become more aware of themselves, and their surroundings (family, society, nature); they would become more responsible in life, and in handling problems with sustainable solutions, while keeping human relationships and human nature in mind.

They would have better critical ability. They would also become sensitive to their commitment towards what they have understood (human values, human relationship and human society). It is hoped that they would be able to apply what they have learnt to their own self in different day-to-day settings in real life, at least a beginning would be made in this direction.

Therefore, the course and further follow up is expected to positively impact common graduate attributes like:

1. Holistic vision of life
2. Socially responsible behaviour
3. Environmentally responsible work
4. Ethical human conduct
5. Having Competence and Capabilities for Maintaining Health and Hygiene
6. Appreciation and aspiration for excellence (merit) and gratitude for all

This is only an introductory foundational input. It would be desirable to follow it up by

a) Faculty-student or mentor-mentee programs throughout their time with the institution

b) Higher level courses on human values in every aspect of living.

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Sports and Yoga or NSS/NCC

Course Code	**:**	**AU-02**
Course Title	**:**	**Sports and Yoga or NSS/NCC**
Number of Credits	**:**	**0 (L: 2, T: 0, P: 0)**
Course Category	**:**	**AU-02**
Prerequisites	**:**	**None**

Course Objectives:

- To make the students understand the importance of sound health and fitness principles as they relate to better health.
- To expose the students to a variety of physical and yogic activities aimed at stimulating their continued inquiry about Yoga, physical education, health and fitness.
- To create a safe, progressive, methodical and efficient activity based plan to enhance improvement and minimise risk of injury.
- To develop among students an appreciation of physical activity as a lifetime pursuit and a means to better health.

Course Contents:

Module I: Introduction to Physical Education

- Meaning & definition of Physical Education
- Aims & Objectives of Physical Education
- Changing trends in Physical Education

Module II: Olympic Movement

- Ancient & Modern Olympics (Summer & Winter)
- Olympic Symbols, Ideals, Objectives & Values
- Awards and Honours in the field of Sports in India (Dronacharya Award, Arjuna Award, Dhayanchand Award, Rajiv Gandhi Khel Ratna Award etc.)

Module III: Physical Fitness, Wellness & Lifestyle

- Meaning & Importance of Physical Fitness & Wellness
- Components of Physical fitness
- Components of Health related fitness
- Components of wellness
- Preventing Health Threats through Lifestyle Change
- Concept of Positive Lifestyle

Module IV: Fundamentals of Anatomy & Physiology in Physical Education, Sports and Yoga

- Define Anatomy, Physiology & Its Importance

- Effect of exercise on the functioning of Various Body Systems. (Circulatory System, Respiratory System, Neuro-Muscular System etc.)

Module V: Kinesiology, Biomechanics & Sports

- Meaning & Importance of Kinesiology & Biomechanics in Physical Edu. & Sports
- Newton's Law of Motion & its application in sports.
- Friction and its effects in Sports.

Module VI: Postures

- Meaning and Concept of Postures.
- Causes of Bad Posture.
- Advantages & disadvantages of weight training.
- Concept & advantages of Correct Posture.
- Common Postural Deformities – Knock Knee; Flat Foot; Round Shoulders; Lordosis, Kyphosis, Bow Legs and Scoliosis.
- Corrective Measures for Postural Deformities

Module VII: Yoga

- Meaning & Importance of Yoga
- Elements of Yoga
- Introduction - Asanas, Pranayama, Meditation & Yogic Kriyas
- Yoga for concentration & related Asanas (Sukhasana; Tadasana; Padmasana & Shashankasana)
- Relaxation Techniques for improving concentration - Yog-nidra

Module VIII: Yoga & Lifestyle

- Asanas as preventive measures.
- Hypertension: Tadasana, Vajrasana, Pavan Muktasana, Ardha Chakrasana, Bhujangasana, Sharasana.
- Obesity: Procedure, Benefits & contraindications for Vajrasana, Hastasana, Trikonasana, Ardh Matsyendrasana.
- Back Pain: Tadasana, Ardh Matsyendrasana, Vakrasana, Shalabhasana, Bhujangasana.
- Diabetes: Procedure, Benefits & contraindications for Bhujangasana, Paschimottasana, Pavan Muktasana, Ardh Matsyendrasana.
- Asthema: Procedure, Benefits & contraindications for Sukhasana, Chakrasana, Gomukhasana, Parvatasana, Bhujangasana, Paschimottasana, Matsyasana.

Module IX: Training and Planning in Sports

- Meaning of Training
- Warming up and limbering down
- Skill, Technique & Style
- Meaning and Objectives of Planning.

- Tournament – Knock-Out, League/Round Robin & Combination.

Module X: Psychology & Sports

- Definition & Importance of Psychology in Physical Edu. & Sports
- Define & Differentiate Between Growth & Development
- Adolescent Problems & Their Management
- Emotion: Concept, Type & Controlling of emotions
- Meaning, Concept & Types of Aggressions in Sports.
- Psychological benefits of exercise.
- Anxiety & Fear and its effects on Sports Performance.
- Motivation, its type & techniques.
- Understanding Stress & Coping Strategies.

Module XI: Doping

- Meaning and Concept of Doping
- Prohibited Substances & Methods
- Side Effects of Prohibited Substances

Module XII: Sports Medicine

- First Aid – Definition, Aims & Objectives.
- Sports injuries: Classification, Causes & Prevention.
- Management of Injuries: Soft Tissue Injuries and Bone & Joint Injuries

Module XIII: Sports / Games

Following subtopics related to any one Game/Sport of choice of student out of: Athletics, Badminton, Basketball, Chess, Cricket, Kabaddi, Lawn Tennis, Swimming, Table Tennis, Volleyball, Yoga etc.

- History of the Game/Sport.
- Latest General Rules of the Game/Sport.
- Specifications of Play Fields and Related Sports Equipment.
- Important Tournaments and Venues.
- Sports Personalities.
- Proper Sports Gear and its Importance.

Text Books/References:

1. Modern Trends and Physical Education by Prof. Ajmer Singh.
2. Light on Yoga By B.K.S. Iyengar.
3. Health and Physical Education – NCERT (11th and 12th Classes)

Course Outcomes: On successful completion of the course the students will be able:

1. To practice Physical activities and Hatha Yoga focusing on yoga for strength,

flexibility, and relaxation.

2. To learn techniques for increasing concentration and decreasing anxiety which leads to stronger academic performance.
3. To learn breathing exercises and healthy fitness activities
4. To understand basic skills associated with yoga and physical activities including strength and flexibility, balance and coordination.
5. To perform yoga movements in various combination and forms.
6. To assess current personal fitness levels.
7. To identify opportModuleies for participation in yoga and sports activities.
8. To develop understanding of health-related fitness components: cardiorespiratory endurance, flexibility and body composition etc.
9. To improve personal fitness through participation in sports and yogic activities.
10. To develop understanding of psychological problems associated with the age and lifestyle.
11. To demonstrate an understanding of sound nutritional practices as related to health and physical performance.
12. To assess yoga activities in terms of fitness value.
13. To identify and apply injury prevention principles related to yoga and physical fitness activities.
14. To understand and correctly apply biomechanical and physiological principles elated to exercise and training.

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SEMESTER – III

Semester – III

Analog Electronics

PCC201	Analog Electronics	**3L:1T:2P**	**5 Credits**

Pre-requisite Basic Electrical Engineering

Objectives:	**Learning Outcomes:**
The Instructor will: 1. Familiarize students with the concepts of analog circuits and give them a comprehensive overview of various amplifiers. 2. Deliver the knowledge of analog circuits by focusing on design and implementation.	The students are expected to have the ability to: 1. Implement the concepts of CMOS Analog Design on real world problems and applications. 2. Design various analog circuits like single stage, differential amplifiers, operational amplifiers, filters for given specifications.

Contents:

Introduction: Example of an electronic system, basic concept of signal, noise etc.

Semiconductor devices: Diode, BJT, MOSFET, their structures, principle of operations, electrical characteristics and their low frequency models, Amplifier models: 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: Estimation of voltage gain, input resistance, output resistance etc. for CE/CS, CB/CG, CC/CD amplifiers, and design procedure for particular specifications.

High frequency analysis: Miller's theorem, high frequency transistor models, frequency response of single stage amplifier (CE/CS, CB/CG, CC/CD amplifiers)

Current mirrors: Basic topology and its variants, V-I characteristics, output resistance and minimum sustainable voltage (VON), maximum usable load, generation of current source.

Differential amplifier: Basic structure and principle of operation, calculation of differential gain, common-mode gain, CMRR and ICMR.

Feedback and Stability: Different feedback topologies such as voltage series, current series, voltage shunt, current shunt, effect of feedback on gain, bandwidth etc., concept of stability.

Operational amplifier: Design of two-stage amplifier, frequency compensation, generalized structure of multistage amplifier.

Oscillators: Basic criteria for oscillation, Phase-shift, and Wien Bridge, oscillators, multivibrators (astable, monostable, bistable).

Reference Books:

1. “Fundamentals of Microelectronics”, B. Razavi, 2nd Edition.

2. “Microelectronic Circuits”, A. S. Sedra and K. C. Smith, 7th Edition

Suggested Experiments:

The lab includes design and analysis of various analog circuits like single-stage amplifiers [3 labs], differential amplifiers [2 labs], operational amplifiers and frequency compensation [3 labs], output stages [2 labs] for given specifications and applications. Students will be introduced with different circuit and design parameters like gain, bandwidth, ICMR, CMRR, PSRR, slew rate and others through DC, AC and transient analysis using simulation software such as SPICE simulations. The lab includes implementation & characterisation of discrete off-the-shelf components using breadboard

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Information and Signals

PCC202	Information and Signals	**3L:1T:0P**	**4 Credits**

Objectives:	**Learning Outcomes:**
1. To develop skills for analyzing signals and systems for any given process.	1. Student will learn the concepts and tools to analyze different type of systems and signals. 2. Student will learn the important aspects of real-time systems such as notion of stability and causality.

Contents:

1. Signals and Systems: signal characterization: discrete amd continuous, energy, power, periodicity, finite duration. system characterization: linearity, time invariance, stability, causality, memory, invertibility.

2. Linear Time-Invariant systems: delta functions, unit step functions, impulse response, convolution, impulse response characterization with respect to system properties such as causality.

3. Fourier Series Representation: eigenfunction of the LTI system, Fourier series representation of periodic signals (continous and discrete), properties of Fourier series: linearity, time shifting, time scaling, conjugation, multiplication, convolution. Parseval relation.

4. Fourier Transform: convergence of Fourier transform, representation of aperiodic signals (continuous and discrete) with Fourier transform, representation of periodic signals (continuous and discrete) with Fourier transform , properties of Fourier transforms: linearity, differentiation in time and frequency, convolution, multiplication, time and frequency shifting, Parseval's relation.

5. Sampling: sampling of a continuous signal, aliasing, Nyquist criteria, interpolation of signal from its samples.

6. Laplace Transform: Notion of complex frequency, Laplace transform, region of convergence, pole-zero (s-plane) plots, properties of Laplace transforms. Unilateral Laplace transform, Initial and Final value theorems, differential equations, system representations: direct, cascade, parallel forms.
7. z-Transform: discrete system and notion of complex frequency, z-transform, region of convergence, pole-zero plots (z-plane), Unilateral Laplace transform, Initial and Final value theorems, difference equations, system representations: direct, cascade, parallel forms

Reference Books:

1. Signals and Systems, Oppenheim, Alan V.; Willsky, Alan S.; Nawab, Hamid; with S. Hamid. Pearson Education (1998).
2. Digital Signal Processing, Sanjit K Mitra, Mc Graw Hill, 2008, Third Edition
3. Digital Signal Processing (Principles, Algorithms, and Applications), John G. Proakis, Dimitria G. Manolakis, Prentice
4. Hall International Inc., 1996, Third Edition

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Network Analysis

PCC203	Network Analysis	**3L:1T:2P**	**5 Credits**

Pre-requisite: Basic Electrical Engineering

Objectives:	**Learning Outcomes:**
The course aims to provide a thorough understanding of network analysis techniques. Students will learn the fundamentals of nodal and mesh analysis, explore key network theorems, and analyze transient and steady-state sinusoidal responses. The course covers network graphs and their applications, as well as two-port networks and their parameters, including Z, Y, h, g, and transmission matrices. It includes combining two-port networks in various configurations and introduces transmission line analysis, leading to the scattering matrix and its applications. Additionally, the course covers network functions, positive real functions, and network synthesis.	1 Analysis of the network using nodal and mesh analysis. 2 Application of network theorems for analysis of dc networks. 3 Understanding of ac circuits. 4 Determine the different two port parameters of circuits and transmission lines. 5 Synthesis of electrical circuits for a given impedance function.

Contents:

1. Overview of network analysis techniques (nodal analysis, mesh analysis).
2. Network theorems.
3. Transient and steady-state sinusoidal response.
4. Network graphs and their applications in network analysis.
5. Two-port networks, Examples of Two-Port networks. Z, Y, h, g, and transmission matrices.
6. Combining two ports in various configurations.
7. Analysis of transmission lines to motivate the scattering matrix. Scattering matrix and its applications in network analysis.
8. Network functions, positive real functions, and network synthesis.

Reference Books:

1. M. E. Van Valkenburg, Network Analysis. Prentice-Hall of India.

2. Kuo, Franklin. Network analysis and synthesis. John Wiley & Sons, 2006.

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Electrical Machines-I

PCC204	Electrical Machines-I	**3L:1T:2P**	**5 Credits**

Pre-requisite Basic Electrical Engineering

Objectives:	**Learning Outcomes:**
The Instructor will: Provide understanding of construction, principle of operation, performance, and control of various electrical machines used in the industry.	The students are expected to have the ability to: 1. Analyze performance of different electrical machines 2. Select various electric machines for field applications

Contents:

General introduction to electrical machines: Magnetic circuits, Concepts of reluctance and permeance, Faraday's law of electromagnetic induction, Lenz's Law and Fleming's rules. Principle of operation of generators and motors. Magnetic curves and their relevance.

Transformers: Constructional features; Ideal transformer and practical transformer, name plate rating, phasor diagrams, equivalent circuit and determination of its parameters from O.C and S.C tests; Per unit parameter values and its importance; Regulation, efficiency and all day efficiency expressions and calculations. Sumpner Test.3-phase Transformer: As a single unit with name plate rating and as a bank of three single phase transformers; Vector groups for various connections; Per phase analysis; Qualitative explanation for origin of harmonic current and voltage and its suppression tertiary winding. Parallel operation conditions and load sharing.

Autotransformer: Basic constructional features; VA conducted magnetically and electrically. Comparative study with two winding transformer.

Three phase Induction machines: Constructional features and types; 3-phase distributed winding production of rotating magnetic field. Concept of slip; Phasor diagram and Development of equivalent circuit and derivation of torque equation, power flow diagram; Typical torque-slip characteristic and influence of different parameters on it; Methods of starting and speed control; Different types of braking circuit arrangement and qualitative explanation. No load and blocked rotor tests.

Single Phase AC motors: Single Phase induction motor: Double revolving field theory and development of equivalent circuit. Methods of starting using auxiliary winding; selection of capacitor value during starting and running.

Universal series motor: constructional features and performance characteristics.

D.C Machines: Constructional features, armature windings - simple lap and wave winding; armature voltage and torque equations. D.C generators: Classifications, performance characteristics; Losses, efficiency and power flow diagram. D.C. motors: Classifications, torque/speed characteristics of different types; Losses, efficiency and power flow diagram. Starting, speed control and braking. Testing and efficiency.

Synchronous machines: Constructional features and types; Operation of synchronous generators and motors connected to bus and phasor diagrams for normal, under and over excited conditions; Power and torque characteristics and capability curves. Parallel operation. Salient pole synchronous machine - phasor diagram and determination of synchronous reactances; starting and speed control of synchronous motors.

Reference Books:

1. Sen, P.C., (2007), Principles of Electric Machines and Power Electronics, 2nd Edition, Wiley
2. Fitzgerald, A.E., Kingsley, C. Jr., Umans, S.D., (2003), Electrical Machinery, 6th Edition, Tata McGraw-Hill AC Machines: Puchstein, Lloyd & Hunte
3. Electrical Machinery: P. S. Bimbhra
4. Electric Machines: I. J. Nagrath & D. P. Kothari.

Suggested List of Experiments:

1. Experiment to determine self and mutual inductances of two coupled inductors
2. Open circuit and short circuit tests on single phase transformer and determination of parameters, regulation and efficiency of transformer
3. Parallel Operation of Two Single Phase Transformers
4. Determination of the characteristic of a DC Shunt Generator
5. Determination of equivalent circuits parameters of a Three Phase Induction Motor
6. Determination of efficiency of DC machine through Hopkinson s Test
7. (a) Scott Connection of Two Single phase Transformers (b) Vector group test
8. Determination of OCC, SCC and ZPF characteristics of a 3-phase Synchronous Machine
9. Synchronization and V-curve of a Synchronous Machine

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SEMESTER – IV

Semester – IV

Environmental Science

AU202	Environmental Science	**3L:0T:0P**	**0 Credits**

Course Objective: People working in industries or elsewhere essentially require the knowledge of environmental science so as to enable them to work and produce most efficient, economical and eco-friendly finished products.

- Solve various engineering problems applying ecosystem to produce eco – friendly products.
- Use relevant air and noise control method to solve domestic and industrial problems.
- Use relevant water and soil control method to solve domestic and industrial problems.
- To recognise relevant energy sources required for domestic and industrial applications.
- Solve local solid and e-waste problems.

Course Content:

Unit-1: Ecosystem

- Structure of ecosystem, Biotic & Abiotic components.
- Food chain and food web.
- Aquatic (Lentic and Lotic) and terrestrial ecosystem.
- Carbon, Nitrogen, Sulphur, Phosphorus cycle.
- Global warming -Causes, effects, process, Green House Effect, Ozone depletion.

Unit–2: Air and, Noise Pollution

- Definition of pollution and pollutant, Natural and manmade sources of air pollution (Refrigerants, I.C., Boiler).
- Air Pollutants: Types, Particulate Pollutants: Effects and control (Bag filter, Cyclone separator, Electrostatic Precipitator).
- Gaseous Pollution Control: Absorber, Catalytic Converter, Effects of air pollution due to Refrigerants, I.C., Boiler.
- Noise pollution: sources of pollution, measurement of pollution level, Effects of Noise pollution, Noise pollution (Regulation and Control) Rules, 2000.

Unit-3: Water and Soil Pollution

- Sources of water pollution, Types of water pollutants, Characteristics of water pollutants Turbidity, pH, total suspended solids, total solids BOD and COD: Definition, calculation.
- Waste Water Treatment: Primary methods: sedimentation, froth floatation, Secondary methods: Activated sludge treatment, Trickling filter, Bioreactor, Tertiary Method: Membrane separation technology, RO (reverse osmosis).
- Causes, Effects and Preventive measures of Soil Pollution: Causes-Excessive use of Fertilisers, Pesticides and Insecticides, Irrigation, E-Waste.

Unit– 4: Renewable sources of Energy

- Solar Energy: Basics of Solar energy. Flat plate collector (Liquid & Air). Theory of flat plate collector. Importance of coating. Advanced collector. Solar pond. Solar water heater, solar dryer. Solar stills.
- Biomass: Overview of biomass as energy source. Thermal characteristics of biomass as fuel. Anaerobic digestion. Biogas production mechanism. Utilisation and storage of biogas.
- Wind energy: Current status and future prospects of wind energy. Wind energy in India. Environmental benefits and problem of wind energy.
- New Energy Sources: Need of new sources. Different types new energy sources. Applications of (Hydrogen energy, Ocean energy resources, Tidal energy conversion.) Concept, origin and power plants of geothermal energy.

Unit-5: Solid Waste Management, ISO 14000 & Environmental Management

- Solid waste generation- Sources and characteristics of: Municipal solid waste, E-waste, biomedical waste.
- Metallic wastes and Non-Metallic wastes (lubricants, plastics, rubber) from industries. Collection and disposal: MSW (3R, principles, energy recovery, sanitary landfill), Hazardous waste.
- Air quality act 2004, air pollution control act 1981 and water pollution and control act1996. Structure and role of Central and state pollution control board.
- Concept of Carbon Credit, Carbon Footprint.
- Environmental management in fabrication industry.
- ISO14000: Implementation in industries, Benefits.

Textbooks / References:

1. S.C. Sharma & M.P. Poonia, Environmental Studies, Khanna Publishing House.
2. S.C. Sharma & M.P. Poonia, Environmental Engineering, Khanna Publishing House, New Delhi.
3. C.N. R. Rao, Understanding Chemistry, Universities Press (India) Pvt. Ltd., 2011.
4. Arceivala, Soli Asolekar, Shyam, Waste Water Treatment for Pollution Control and
5. Reuse, Mc-Graw Hill Education India Pvt. Ltd., New York, 2007, ISBN:978-07-062099-
6. Nazaroff, William, Cohen, Lisa, Environmental Engineering Science, Willy, New York, 2000, ISBN 10: 0471144940.
7. O.P. Gupta, Elements of Environmental Pollution Control, Khanna Publishing House, New Delhi
8. Rao, C. S., Environmental Pollution Control and Engineering, New Age International Publication, 2007, ISBN: 81-224-1835-X.
9. Rao, M. N.Rao, H.V.N, Air Pollution, Tata Mc-Graw Hill Publication, New delhi, 1988, ISBN: 0-07- 451871-8.
10. Frank Kreith, Jan F Kreider, Principles of Solar Engineering, McGraw-Hill, New York; 1978, ISBN: 9780070354760.
11. Aldo Vieira, Da Rosa, Fundamentals of renewable energy processes, Academic Press Oxford, UK; 2013. ISBN: 9780123978257.
12. Patvardhan, A.D, Industrial Solid Waste, Teri Press, New Delhi, 2013, ISBN:978- 81-7993-502-6
13. Metcalf & Eddy, Waste Water Engineering, Mc-Graw Hill, New York, 2013, ISBN: 077441206.

14. Keshav Kant, Air Pollution & Control, Khanna Publishing House, New Delhi

Open source software and website address:

1. www.eco-prayer.org
2. www.teriin.org
3. www.cpcp.nic.in
4. www.cpcp.gov.in
5. www.indiaenvironmentportal.org.in
6. www.whatis.techtarget.com
7. www.sustainabledevelopment.un.org
8. www.conserve-energy-future.com

Teachers should use the following strategies to achieve the various outcomes of the course.

- Different methods of teaching and media to be used to attain classroom attention.
- Massive open online courses (MOOCs) may be used to teach various topics/sub topics.
- 15-20% of the topics which are relatively simpler of descriptive in nature should be given to the students for self-learning and assess the development of competency through classroom presentations.
- Micro-projects may be given to group of students for hand-on experiences.
- Encouraging students to visit to sites such as Railway station and research establishment around the institution.

Course Outcomes: At the end of the course student will be able to

1. Understand the ecosystem and terminology and solve various engineering problems applying ecosystem knowledge to produce eco – friendly products.
2. Understand the suitable air, extent of noise pollution, and control measures and acts.
3. Understand the water and soil pollution, and control measures and acts.
4. Understand different renewable energy resources and efficient process of harvesting.
5. Understand solid Waste Management, ISO 14000 & Environmental Management.

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Digital Electronics

PCC206	Digital Electronics	**3L:1T:2P**	**5 Credits**

Pre-requisite: Basic Electronics Engineering

Objectives:	**Learning Outcomes:**
1. To understand the fundamentals of digital logic and develop an ability to design basic digital circuits.	1. The students will be able to understand binary number system and digital logic which is the basics of computing system. 2. Students will be able to design simple digital circuits and analyze them.

Contents:

1. Digital Systems and Binary numbers: Binary, decimal, octal, hexadecimal number systems, number base conversions, complements, signed binary numbers, binary logic.
2. Boolean Algebra and Logic Gates: Basic theorems and properties of Boolean algebra, Boolean functions, canonical and standard forms, digital logic gates and integrated circuits
3. Gate Level Minimization: K-Map method, POS and SOP simplifications, don't care conditions, NAND and NOR implementations.
4. Digital Logic Families: CMOS logic, voltage levels, noise margin, power dissipation, fan-in and fan-out.
5. Introduction to HDL: Basic building blocks and syntax of VHDL / Verilog, different modeling styles – structural, behavioral, writing test bench.
6. Combinational Logic: Design and analysis of combinational circuits – adders, subtractors, multiplier, magnitude comparators, encoders, decoders and multiplexers.
7. Sequential Logic: Design and analysis of sequential circuits – latches, flip-flops, registers and counters.
8. Lab Experiments: Designing arithmetic circuits (half-adder, full-adder, multiplier), universal shift registers, frequency dividers, ALU, Mealy and Moore Machines.

Reference Books:

1. Ciletti, Michael D., and M. Morris Mano. Digital design. Hoboken: Prentice-Hall, 2007.
2. Floyd, Thomas L. Digital fundamentals, 10/e. Pearson Education India, 2011.
3. Jain, R. P. Modern digital electronics. Vol. 1. No. 10. Tata McGraw-Hill Education, New Delhi, 2003.

Video Lectures:

1. Roychoudhury, D., Digital Systems Design, Department of Electrical Communication Engineering, Indian Institute of Technology Kharagpur (https://nptel.ac.in/courses/117/105/117105080/)

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Control Systems

PCC207	Control Systems	**3L:1T:2P**	**5 Credits**

Pre-requisite Basic Electrical Engineering

Objectives:

This course aims to provide students with a solid foundation in control systems, focusing on the analysis and design of various system models and feedback control strategies. Students will learn to mathematically represent mechanical, electrical, thermal, and pneumatic systems using state variable and transfer function models. The course covers closed-loop system analysis, time response, steady-state error, and disturbance rejection. Emphasis is placed on feedback control characteristics, stability criteria, sensitivity analysis, and robustness. Additionally, students will explore basic feedback control modes, frequency response analysis, and compensation techniques.

Contents:

1. Introduction to the control problem, Control System Components: Sensors, Actuators, Computational blocks.
2. Mathematical representation of systems, state variable model, transfer function model. Transfer function and state variable models of suitable mechanical, electrical, thermal and pneumatic systems. Linearization, Solution of state equations of LTI System.
3. Closed loop systems, Block diagram and signal flow analysis.
4. Time response of first and second order system, steady state error analysis. Performance specifications in the time domain, disturbance rejection.
5. Basic Characteristics of feedback control systems: Concept of BIBO stability, Routh stability criterion.
6. Definition of sensitivity, effects of feedback on sensitivity, It's analysis and robustness.
7. Basic modes of feedback control: Proportional, Integral, Derivative.
8. Basics of Root locus and its application.
9. Frequency response analysis: Polar plots, Bode plots, Nyquist stability criterion. Non-minimum phase systems.
10. Performance specifications in frequency domain, Frequency domain methods of design.
11. Lead, lag, lead-lag compensation.

Reference Books:

1. Ogata, Katsuhiko. Modern control systems. Prentice Hall, 1997.

2. Nise, Norman S. Control systems engineering. John Wiley & Sons, 2020.

Learning Outcomes:

1. Mathematically represent and model dynamic systems using state variable and transfer function approaches for mechanical, electrical, thermal, and pneumatic systems.

2. Analyze and design closed-loop control systems, including block diagram and signal flow analysis, time response, and steady-state error analysis.

3. Understand and apply fundamental feedback control concepts, including BIBO stability, Routh stability criterion, and sensitivity analysis.

4. Perform frequency response analysis using polar plots, Bode plots, and the Nyquist stability criterion, and design compensators such as lead, lag, and lead-lag for enhanced system performance.

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Power Electronics

PCC208	Power Electronics	**3L:1T:2P**	**5 Credits**

Pre-requisite Basic Electrical Engineering

Objectives:	**Learning Outcomes:**
The Instructor will: Provide fundamentals of power electronic circuits and applications	The students are expected to have the ability to: Design and analyze various types of power electronic converter circuits for applications in AC as well as DC circuits

Contents:

Introduction: Need for power conversion with efficient, high frequency, lightweight converters; Power electronic converters: Classifications and scope;

Power semiconductor switches: power/fast diodes, SCR, and transistors (BJT, MOSFET and IGBT) Ratings, static and dynamic characteristics, drive and switching aid circuits and cooling; isolation; protection;

DC to DC conversion: Choppers: non-isolated: Buck, Boost and Buck- Boost converters; circuit configuration and analysis with; continuous and discontinuous loads; H-bridge converter multi-quadrant operation; isolated: forward, fly-back converters; example of a typical drive circuit;

AC to DC conversion: Rectifiers: controlled/half-controlled/uncontrolled: single phase and three phase operation, Operation with R, R-L, back emf load; power factor, harmonics and effect of source inductance; Cascade operation; dual converters; a typical trigger / drive circuit;

DC to AC conversion: Inverters: current source and voltage source inverters, active and reactive power handling; single phase and three phase voltage source and PWM inverters; PWM techniques; active front-end rectifier; a typical trigger / drive circuit;

AC to AC conversion: Single phase AC static switches; transient-free switching of inductive loads; voltage regulators; cycloconverter;

Reference Books:

1. Rashid, M. H., (2004), Power Electronics Circuits, Devices, and Applications, 3rd Edition, Pearson Education Inc.

2. Hart, D. W., (2011), Power Electronics, Tata McGraw-Hill Education Private Limited.

3. Mohan, N., (2007), First Course on Power Electronics and Drives, MNPERE

Suggested List of Experiments:

1. Study of 1-phase AC to DC controlled converter (both fully controlled and half controlled).
2. Study of 3- phase AC to DC full controlled converter.
3. Study of a Triac based single phase AC regulator and determination of Thyristor switching characteristics and pulse transformer characteristics.
4. Study of MOSFET/ IGBT based DC to DC converter (buck, boost and buck-boost with nonisolated output voltage).
5. Study of a 3-phase PWM voltage source inverter with fixed (50 Hz) output frequency and study of a non-PWM type voltage source inverter with 180-degree conduction of switches.
6. Study of an inverter fed adjustable speed drive for a 3-phase induction motor.

7. Study of a Thyristor based DC-drive with closed loop speed control.
8. Study of an industrial type fly-back DC to DC converter with isolated and regulated output voltage.
9. Study of a single phase PWM AC to DC converter.

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Electromagnetic Fields

PCC209	Electromagnetic Fields	**3L:1T:0P**	**4 Credits**

Pre-requisite: Physics, Basic Electrical Engineering

Objectives:	**Learning Outcomes:**
The Instructor will: 1. Familiarize behaviour of Electromagnetic wave propagation in different medium and its application to solving practical electromagnetic fields problems 2. Provide basic understanding about transmission line and radiating systems for solving engineering electromagnetic problems 3. Provide basic understanding of wave propagation used in practical wireless propagation systems.	The students are expected to have the ability to: 1. Formulate and analyse problems involving lossy media with planar boundaries using uniform plane waves. 2. Solve engineering problems involving transmission lines, metallic/dielectric waveguides. 3. Obtain basic understanding of different radiating systems and be able to use these in the design of rudimentary wireless communications systems

Contents:

Review of Maxwell's equations: Review of Maxwell's Equation, time-harmonic fields, scalar and vector potentials, boundary conditions, Uniform plane wave

Plane waves at boundaries: Plane wave reflection and refraction at boundaries: Normal and oblique incidence, Brewster angle

Plane waves in dispersive media: quarter wave matching, wave propagation in dispersive media

Transmission Lines theory: Transmission line parameters and equations, Input impedance, standing wave ratio and power

Transmission Lines application: Smith chart, Impedance matching, Applications of transmission lines, Transient on transmission lines

Guided wave: TE, TM and TEM waves, parallel-plate waveguide

Waveguides: rectangular and cylindrical waveguides, waveguide resonators, dielectric guides

Antennas: Hertzian dipole, half-wave dipole and quarter-wave monopole antennas, small loop antenna, antenna characteristics and arrays

Wave propagation: Ground wave propagation, ionospheric propagation

Reference Books:

1. Hayt, W. H. & Buck, J. A., (2015), Engineering Electromagnetics, 6th Edition, Tata McGraw-Hill
2. Sadiku, M. N. O., (2015), Principles of Electromagnetics, 6th edition, Oxford University Press
3. David K. Cheng, (1989), Fields and Waves Electromagnetics, 2nd edition, Pearson Education

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PEC202	Electric Machines – II or Digital Signal Processing	**3L:1T:0P**	**4 Credits**

Electric Machines – II

Pre-requisite: Basic Electrical Engineering

Objectives:	**Learning Outcomes:**
The Instructor will: Provide advanced understanding and analysis of various electrical machines.	The students are expected to have the ability to: 1. Analyze both the transient and steady state performance of different electrical machines 2.Analyze both the transient and steady state performance of some of the special electrical machines

Contents:

Three winding transformer; Unbalanced operation of three phase transformer; Switching-in transients and mechanical forces. Electromechanical energy conversion: Field energy- energy and co-energy; Torque/force in a singly excited and multiple excited electromechanical systems and applications, AC windings.

Circuit analysis of electrical machines: Development of circuit models from dc machine and synchronous machine.

Impedance matrix; instantaneous and phasor variables; real-coil and pseudo-stationary coil, expressions for torque and power, transformation of variables with power invariance, examples; general two-axis machine. Extension of two-axis models to different machines. D.C machines: Flux and mmf waves; Commutation and armature reaction; Dynamic equations, block diagrams and transfer functions. Induction machines: Deep-bar and double-cage construction; Machine equations in stationary reference frame (d-q axis model), dynamic and steady state performance, behavior under asymmetrical supply voltages.

Synchronous machines: Winding inductances; Machine equations in rotor reference frame (d-q axis model); Sudden three phase short circuit and transient circuit model; Steady state operation; Synchronous machine dynamics.

Reluctance Machines: Synchronous reluctance, stepping motors and switched reluctance machines, principles of operation and models for operating characteristics. Steady-state and dynamic performance. PM machines: Permanent magnet material, Basic analysis of magnetic circuit with permanent magnets, Steady-state and dynamic performance of PM synchronous machines and Brushless DC machines.

Reference Books:

1. Sen, P.C., (2007), Principles of Electric Machines and Power Electronics, 2nd Edition, Wiley
2. Fitzgerald, A.E., Kingsley, C. Jr., Umans, S.D., (2003), Electrical Machinery, 6th Edition, Tata McGraw-Hill
3. Electrical Machinery: P. S. Bimbhra

4. Electric Machines: I. J. Nagrath & D. P. Kothari.
5. Performance and Design of Alternating Current Machines: M.G. Say

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Digital Signal Processing

Prerequisite: Information and Signals

Objectives:	**Learning Outcomes:**
1. To develop skills for analyzing and synthesizing algorithms and systems that process discrete time signals, with emphasis on realization and implementation	1. Digital signal processing is one of the most important and useful tools an electrical engineer could have. It impacts all modern aspects of life and sciences; from communication, entertainment to health and economics. 2. Student will learn the concepts and techniques of modern digital signal processing which are fundamental to all the above applications

Contents:

1. Sampling and reconstruction, sampling of band-pass signals, The discrete Fourier transform (DFT), Sampling of the discrete time Fourier transform, properties of the DFT, linear convolution using the DFT, Fourier analysis of the signals using the DFT, Direct computation of the DFT, Decimation-in-time FFT algorithms, Decimation-in-frequency FFT algorithm.
2. Design of FIR filters: FIR filters with linear phase, design of FIR filters by windowing and frequency sampling. Design of some special FIR filters, Real Time Implementation of FIR filters.
3. Design of IIR filters: Introduction to IIR filter design, Design of continuous time low pass filters, transformation of continuous time filters to discrete time filters, design examples for low pass IIR filters, Frequency transformations of low pass filters.
4. Multirate signal processing: sampling rate conversion, implementation of Multirate systems, filter design for Multirate systems
5. Finite wordlength effects: Number representation, statistical analysis of quantization error, quantization of Fixed-point and Floating-point numbers, A/D and D/A conversion, A/D conversion noise analysis, quantization of filter coefficients, Effects of finite wordlength on digital filters.
6. Radom signal processing: Spectral analysis of stationary processes, Optimum linear filters, Linear prediction, Forward and Backward linear prediction, Solution of the Normal Equations, Properties of the Linear Prediction-Error Filters, Wiener Filters for Filtering and Prediction and all-pole signal modeling.

Reference Books:

1. Digital Signal Processing, Sanjit K Mitra, Mc Graw Hill, 2008, Third Edition

2. Applied Digital Signal Processing, D. Manolakis and V. Ingle, Cambridge University Press, 2011

3. Digital Signal Processing (Principles, Algorithms, and Applications), John G. Proakis, Dimitria G. Manolakis, Prentice Hall International Inc., 1996, Third Edition.

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SEMESTER – V

Semester – V

Entrepreneurship and Start-ups

HS301	Entrepreneurship and Start-ups	**3L:0T:0P**	**3 Credits**

Course Structure:

1: Introduction to Entrepreneurship

Objective: Understand the fundamental concepts of entrepreneurship.

Learning Outcomes:

- Define entrepreneurship and its significance.
- Explore historical perspectives on entrepreneurship.
- Identify key theories related to entrepreneurship.

2: Idea Generation and Evaluation

Objective: Develop skills in generating and evaluating business ideas.

arning Outcomes:

- Generate innovative business ideas.
- Apply criteria for evaluating the feasibility and viability of ideas.
- Understand the role of creativity and problem-solving in idea generation.

3: Business Planning

Objective: Learn how to create effective business plans.

Learning Outcomes:

- Develop a business plan covering marketing, human resources, and operations.
- Understand financial planning and projections.
- Explore the use of AI and technology in business planning.

4: Financing and Funding

Objective: Explore financing options for startups.

Learning Outcomes:

- Understand different sources of funding (e.g., bootstrapping, venture capital, angel investors).
- Evaluate the pros and cons of each funding method.
- Create a financial plan for a startup.

5: Field Work and Projects

Objective: Apply theoretical knowledge to real-world scenarios.

Learning Outcomes:

- Conduct field research (interviews, surveys, observations) related to entrepreneurship.
- Collaborate on group projects that simulate startup challenges.
- Present findings and recommendations.

6: Case Studies and Contemporary Topics

Objective: Analyze real-world case studies and explore current trends.

Learning Outcomes:

- Analyze entrepreneurial success stories and failures.
- Discuss contemporary topics (e.g., sustainability, social entrepreneurship, disruptive technologies).
- Reflect on ethical considerations in entrepreneurship.

Reference Books:

1. "The Lean Startup" by Eric Ries
2. "Disciplined Entrepreneurship: 24 Steps to a Successful Startup" by Bill Aulet
3. "Venture Deals: Be Smarter Than Your Lawyer and Venture Capitalist" by Brad Feld and Jason Mendelson
4. Hisrich, R. D., Peters, M. P., & Shepherd, D. A. (2019). *Entrepreneurship* (10th ed.). McGraw-Hill Education.
5. Blank, S. G., & Dorf, B. (2012). *The Startup Owner's Manual: The Step-by-Step Guide for Building a Great Company*. K&S Ranch Inc
6. "Blue Ocean Strategy" by W. Chan Kim and Renée Mauborgne.
7. "Business Model Generation" by Alexander Osterwalder and Yves Pigneur.
8. "Business Plans for Dummies" by Paul Tiffany and Steven D. Peterson.
9. "Operations Management" by Jay Heizer and Barry Render.
10. "Human Resource Management" by Gary Dessler.
11. "Venture Deals" by Brad Feld and Jason Mendelson.
12. "Financial Intelligence for Entrepreneurs" by Karen Berman and Joe Knight.
13. "The Innovator's Dilemma" by Clayton Christensen.
14. "Zero to One" by Peter Thiel.
15. "Good to Great" by Jim Collins.
16. Entrepreneurship 11th Edition by Robert Hisrich, McGraw-Hill Higher Education, Year 2020, Print ISBN 9781260043730, 1260043738, eText ISBN 9781260564112, 1260564118
17. Disciplined Entrepreneurship: 24 Steps to a Successful Startup, Expanded & Updated 2nd Edition by Bill Aulet
18. Entrepreneurship: The Practice and Mindset 2nd Edition by Heidi M. Neck; Christopher P. Neck; Emma L. Murray, SAGE Publications, Inc, Print ISBN 9781544354620, 1544354622, e-text ISBN 9781544354644, 1544354649, Year2021

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Indian Constitution

AU301	Indian Constitution	**3L:0T:0P**	**0 Credits**

Pre-requisite

Objectives:	**Learning Outcomes:**
1. To impart a comprehensive understanding of the Indian Constitution 2. To make realize the Fundamental Rights and Fundamental Duties of aa Indian Citizen 3. To understand the Organs of the Government of India 4. To understand the relationship and Functioning of the Union and the State in Indian Federal System 5. To make understand the democratic form of government 6. To develop an understanding of the Electoral Process, Emergency Provisions, and The Constitutional Amendment Procedure 7. To teach the Affirmative Action of the Government.	1. The student will be able to develop an understanding of the Indian Constitution as the Fundamental Law of the Land 2. The student will be able to preserve his/her Fundamental Rights and Fundamental Duties in Letter and Spirit required for nation building 3. The student will be able to understand the organs and functions of government 4. The student will be able to understand the Indian Political System, the constitution of government, and the Powers and functions of the Union, State, and Local government 5. The student will be able to understand the true nature of democracy 6. The student will be able to understand the Electoral Process, Emergency Provisions, and Constitutional Amendment Procedure

Contents:

- **The Indian Constitution;** meaning, genesis of the Indian Constitution, Preamble-Salient features, Components, types of Constitution, Functions, Basic Structure of the Constitution, Constitutionalism.
- **The Union and its Territory**, Citizenship, Fundamental Rights, and Fundamental Duties, Directive Principles of State Policy
- **The Union Territory;** The Panchayats, The Municipalities, Composition, Wards, , Co-operative societies, definition, number and term of members of Board and its Office Bearers, relationship between the Union and the State, The SC and ST- Affirmative Action
- **Organs of Government;** The Executive, The Legislative Union, and The Judiciary
- **The States;** The Executive, The Governor – Executive Power of the State, Appointment of Governor, Terms of Office of Governor, Qualifications for appointment as Governor, conditions of Governor's Office, Council of Ministers, Duties of Chief Minister, Judiciary High Court, Subordinate High Court
- **Relation between the Union and the State**; Legislative relations, and administrative relations
- **Finance, Property, Contracts, Rights, Liabilities, Obligations, Suits, Right to Property**
- **Official Language of the Union**
- **Amendment of the Constitution;** Power of Parliament to amend the Constitution and procedure

References Books:

1. Agarwal, R., C, (1977). Indian Political System. New Delhi. S. Chand & Company.
2. Basu, D., D. (2008). Introduction to the Constitution of India. New Delhi. Prentice Hall of India.
3. Chakravarthy, B. (2008). Indian Constitution and Politics. New Delhi. Sage India.
4. Ghosh, Peu. (2017). Indian Government and Politics. New Delhi. Prentice Hall of India Learning.
5. Pandey, J., N. (2018). The Constitution of Law of India. Allahabad, Central Law Agency.
6. Pylee., M., V. (2005). An Introduction to the Constitution of India. 4th Edition. New Delhi. Vikas Publishing House.

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Power Systems-I

PCC301	Power Systems-I	**3L:1T:2P**	**5 Credits**

Pre-requisite Basic Electrical Engineering

Objectives:	**Learning Outcomes:**
The Instructor will: 1. Provide an understanding of the functionalities of various components of the modern power system and their modelling 2. Give exposure to modern methodologies to enhance the efficiency, economy, and controllability of the existing power system	The students are expected to have the ability to: 1. Model and evaluate the performance of a power system 2. Propose converter topologies and their control strategies for enhancing the power system performance

Contents:

Transmission line parameters – Resistance, Inductance, Capacitance and Conductance. Inductance of single phase line, inductance of three phase line with symmetrical and unsymmetrical spacing, concept of GMD and GMR. Inductance of composite conductor systems – stranded conductors, bundle conductor and Double circuit lines.

Capacitance of single phase line, capacitance of three phase lines with symmetrical and unsymmetrical spacings, capacitance calculation for double circuit line and bundle conductor. Effect of earth on capacitance calculation. Skin effect and proximity effect. Interference between power and communication lines.

Line representation – Representation of short, medium and long lines, Pi and T models. A, B, C, D constants of transmission lines and their measurement.

Travelling wave interpretation of long line equations, tuned lines.

Transmission line structure- Types of conductors, line supports – poles, towers, stay& Guy wires

Sag And Tension calculations, stringing chart, sag template

Insulators – Materials of insulators, types of insulators – Pin and Disc type – their applications

Underground Cables – Construction of cables, single and multicore cables, different types, capacitance of belted cables, dielectric loss in cables, heating of cables.

Legal aspects of electricity supply- Electricity acts, rules and codes. Standards followed in power supply, environmental and safety measures

Commercial aspects of electricity supply – Expenditure in power Utility. Factors influencing tariffs, types of consumers, different types of tariffs.

Administrative aspects of electricity supply- Development of power sector in India. Administrative set up and organisations in power sector. Stages involved in power planning-

load analysis, load management & load forecasting.

Reference Books:

1. Power System Analysis, John J. Grainger & William D. Stevenson Jr, McGraw Hill1994;
2. Power System Analysis and design, J. Duncan Glover, M. Sarma, 2nd edition, PWS Publishing Co Boston 2001;
3. Power System Engineering, D. P. Kothari & I. J. Nagrath, Tata McGraw Hill, 2008.

List of Suggested Experiments:

1. Synchronous Machine
2. Induction Generator
3. Three Phase-Three windings Transformer
4. i) Overcurrent Relay
   ii) Short circuit test of an Alternator
5. i) Directional Relay
   ii) Digital distance Relay
6. Percentage Biased Differential Relay
7. Impulse Voltage Generator
8. Study of Corona Discharge and AC Breakdown Voltage for Different Electrode-Gap Geometry
9. i) Study of wind turbine generator
   ii) Fuel Cell System
10. Study of Micro-hydel pumped storage system

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Communication Systems

PE303	Communication Systems	**3L:1T:0P**	**4 Credits**

Pre-requisite: Information and Signals

Objectives:	**Learning Outcomes:**
1. To develop understanding of the concepts related to transmission and reception techniques for communications	1. Communication Systems course will help the students to analyze and design basic communication systems. 2. Student will learn the concepts related to comparison and contrasting the strengths and weaknesses of various communication techniques.

Contents:

1. Introduction to Communication Systems: Basic building blocks of communication systems, Review of probability and random process, Gaussian and white noise characteristics, power spectral density of noise, noise through LTI systems.
2. Analog Modulation: Need for modulation, Amplitude Modulation (AM), frequency division multiplexing, spectrum of AM, Angle Modulation, spectrum of angle modulated signal, Noise in AM and FM systems, Pre-emphasis and De-emphasis, Threshold effect in angle modulation
3. Pulse Modulation: Sampling theorem and time-division multiplexing, Pulse modulation techniques, generation and detection of pulse modulation
4. Digital Transmission at Baseband: Quantization, pulse code modulation, line codes, spectral characteristics of line codes, Matched filter receiver, inter-symbol interference, eye-patterns, Nyquist's criterion for ISI free transmission, equalization.
5. Digital Transmission at Passband: Binary digital modulation, QAM, signal constellation, spectral characteristics of digital modulated signals, digital receiver design - correlator receiver, optimal detectors, bit error rate performance analysis over AWGN channels, power and bandwidth efficiency.

Reference Books:

1. Communication Systems, S. Haykin and M. Moher, Wiley Press, 2009, Fifth Edition
2. Modern Digital and Analog Communication Systems, B. P. Lathi, Z. Ding and H. M. Gupta, Oxford University Press, 2017, Fourth Edition.
3. Fundamentals of Digital Communication, U. Madhow, Cambridge University Press, 2008, First Edition.

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SEMESTER – VI

Semester – VI

Measurements and Instrumentation

PC301	Measurements and Instrumentation	**3L:1T:2P**	**5 Credits**

Pre-requisite: Basic Electrical Engineering

Objectives:	**Learning Outcomes:**
This course covers measurement and instrumentation principles and techniques, including calibration methods, voltage and current measurements, error analysis, compensation techniques, power and energy measurement methods, potentiometers, and instrument transformers. It also covers analog-to-digital conversion techniques and digital instrumentation, providing students with a comprehensive understanding of these techniques.	1. Apply calibration procedures effectively to ensure accurate measurements using various instruments. 2. Identify and analyze measurement errors, implementing appropriate compensation techniques for improved accuracy. 3. Utilize principles of power and energy measurement to calibrate relevant instruments and accurately assess power consumption. 4. Demonstrate proficiency in analog-to-digital conversion techniques and effectively employ digital instrumentation for data acquisition and analysis.

Contents:

1. Basics of Measurement and Instrumentation, Instrument Examples: Galvanometer, Accelerometer etc; calibration methods.
2. Voltage and Current Measurements; Theory, calibration, application.
3. Errors and compensation. Power and Energy Measurement and its errors, Methods of correction, LPF wattmeter, Phantom loading.
4. Induction type KWH meter; Calibration of wattmeter, energy meter.
5. Potentiometer and Instrument Transformer: DC and AC potentiometer, C.T. and V.T. construction, theory, operation, characteristics.
6. Analog-to-Digital Conversion (ADC), Staircase Ramp Compensation, Integrator-based ADC, Delta-Pulse-Modulation-based ADC.
7. Digital Instrumentation.

Reference Books:

1. E. A. Doebelin, 'Measurement Systems - Applications and Design', Tata McGraw Hill, New York, 1990.
2. A. K. Sawhney, 'A Course in Electrical & Electronic Measurement and Instrumentation', Dhanpat Rai and Co (P) Ltd., 2004.
3. E. W. Golding and F. C. Widdis, 'Electrical Measurements & Measuring Instruments', A. H. Wheeler & Co, 1994.
4. A. J. Bouwens, 'Digital Instrumentation', Tata McGraw Hill, 1997.

Microprocessor and Microcontrollers

PE303/PC302	Microprocessor and Microcontrollers	**3L:1T:0P**	**4 Credits**

Pre-requisite: Digital Electronics

Objectives:	**Learning Outcomes:**
The teacher will introduce the students to 8-bit microprocessors and microcontrollers, their various peripherals, and assembly language programming	The students should be able to: 1. Write assembly language programs for microprocessors and microcontrollers 2. Design typical applications involving microprocessors/ microcontrollers

Contents:

Microprocessors: Historical background; Organization & Architectural Features of Microprocessor & Microcontrollers;

The Instruction Set: Instruction format, addressing modes; Assembly language programming of 8085 and 8051;

Interfacing of memory devices; Data transfer techniques and I/O ports; Interfacing of keyboard and display devices;

Programmable Interrupt and DMA controllers;

Interfacing of sensors, transducers, actuators, A/D & D/A Converters,

Analog Signal Conditioning Circuits, Data acquisition systems;

Standard Interfaces – RS232, USB;

Development aids and troubleshooting techniques;

Application examples; Advanced microprocessors and microcontrollers.

Reference Books:

1. Gaonkar R., Microprocessor Architecture, Programming, and Applications with the 8085, Penram
2. Pal A., Microprocessors: Principles and Applications, TMH
3. Ayala K. J., The 8051 MicrocontrollerArchitecture, Programming & Applications, Penram
4. Mazidi and Mazidi, Microcontroller and Embedded Systems, Pearson Education
5. Kapadia, R., 8051 Microcontroller and Embedded Systems, Jaico

Bouquet Department Electives (DEL) 3rd Year

Building Cyber Physical Systems

PE304	Building Cyber Physical Systems	**3L:0T:2P**	**4 Credits**

Pre-requisite Embedded systems, Wireless networking, software development, Data analytics

Objective	Learning Outcome:
1. Introduce modelling of CPS 2. Develop ability to analyse and simulate CPS systems	1. Analyze, interpret and provide solutions to real-life problems related to Cyber Physical Systems domain. 2. Develop competency for designing engineered systems that are built from seamless integration of physical system and cyber system. 3. Develop expertise in one or more application domains relevant to Cyber Physical Systems.

Contents:

Cyber-Physical Systems (CPS) in the real world, Basic principles of design and validation of CPS, **CPS HW platforms:** Processors, Sensors, Actuators, CPS Network, CPS SW stack RTOS, Scheduling Real Time control tasks.

Principles of Automated Control Design: Dynamical Systems and Stability, Controller Design Techniques. **Stability Analysis:** CLFs, MLFs, stability under slow switching, Performance under Packet drop and Noise.

CPS: From features to software components, Mapping software components to ECUs, CPS Performance Analysis : effect of scheduling, bus latency, sense and actuation faults on control performance, network congestion

Formal Methods for Safety Assurance of Cyber-Physical Systems: Advanced Automata based modelling and analysis: Basic introduction and examples, Timed and Hybrid Automata, Definition of trajectories. Formal Analysis: Flow pipe construction, reachability analysis, Analysis of CPS Software, Weakest Pre-conditions, Bounded Model checking

Hybrid Automata Modelling: Flow pipe construction using Flow star, Space X and Phaver tools, CPS SW Verification: Frama-C, CBMC, **Secure Deployment of CPS:** Attack models, Secure Task mapping and Partitioning, State estimation for attack detection, Automotive

Case study: Vehicle ABS hacking, Power Distribution

Text/ Reference Book

- E. A. Lee and S. A. Seshia, "Introduction to Embedded Systems: A Cyber-Physical Systems Approach", 2011.
- R. Alur, "Principles of Cyber-Physical Systems," MIT Press, 2015.
- T. D. Lewis "Network Science: Theory and Applications", Wiley, 2009.
- P. Tabuada, "Verification and control of hybrid systems: a symbolic approach", Springer-Verlag 2009.
- C. Cassandras, S. Lafortune, "Introduction to Discrete Event Systems", Springer 2007.
- Constance Heitmeyer and Dino Mandrioli, "Formal methods for real-time computing", Wiley publisher, 1996.

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EEC301	Summer Internship II / Minimum duration of 1-month internship in industry/ Design credit during the summer vacation		

Refer Appendix- II

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Mechatronics/ New and Renewable Energy

PE304	Mechatronics/ New and Renewable Energy	**3L:1T:2P**	**5 Credits**

Pre-requisite: Basic Electrical Engineering

Objectives:	**Learning Outcomes:**
This course aims provides a solid foundation in mechatronic systems, covering key elements like physical systems modeling, sensors, actuators, signal processing, logic systems, data acquisition, hardware interfacing, instrumentation, and control systems. It emphasizes practical applications, hands-on design using CAD software, and laboratory work on interfacing, motion control, and integrating mechatronic components.	**1.** Model and analyze physical systems, and effectively use sensors and actuators in mechatronic applications. **2.** Design and interface microprocessor-based controllers and microcontrollers with various sensors and actuators. **3.** Integrate hardware and software components to develop and control mechatronic systems. **4.** Apply CAD software for the design and development of mechatronic products, with practical experience in laboratory settings.

Contents:

1. Introduction to key elements of Mechatronic products - Physical Systems Modeling, Sensors and Actuators, Signals and Systems.
2. Computers and Logic Systems, Software and Data Acquisition; Mechatronic Design Approach, System Interfacing, Instrumentation and Control Systems.
3. Microprocessor-Based Controllers, Microcontroller interfacing and programming, Interfacing with sensors and actuators, driver circuits, Stepper and servo motion control.
4. Hardware-Software Integration: Design and selection of mechatronic elements namely sensors like encoders and resolvers; stepper and servomotors, ball screws, solenoid like actuators, and controllers with applications to CNC systems, robotics, consumer electronic products etc.
5. Design of a mechatronic product using CAD software.
6. Laboratory work will be hands-on Microcontroller & Microprocessor interfacing and programming, Motion controller, motors, sensors, and actuators.

Reference Books:

1. Isermann, Rolf. Mechatronic systems: fundamentals. Springer Science & Business Media, 2005.
2. Bishop, Robert H. Mechatronics: an introduction. CRC Press, 2017.

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New and Renewable Energy

Pre-requisite:Physics and Chemistry

Objectives:	**Learning Outcomes:**
To develop an ability to acquire an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	1. Student will learn to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors. 2. Student will acquire an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions

Contents:

Solar angles, day length, angle of incidence on the tilted surface; Sun path diagrams; Shadow determination; Extraterrestrial characteristics; Effect of earth atmosphere; Measurement & estimation on horizontal and tilted surfaces; Analysis of Indian solar radiation data and applications. Flat-plate Collectors - Effective energy losses; Thermal analysis; Heat capacity effect; Testing methods; Evacuated tubular collectors; Air flat-plate Collectors: types; Thermal analysis; Thermal drying. Selective Surfaces -Ideal coating characteristics; Types and applications; Anti-reflective coating; Preparation and characterization.

Concentrating Collector Designs - Classification, Tracking systems; Compound parabolic concentrators; Parabolic trough concentrators; Concentrators with point focus; Heliostats; Comparison of various designs: Central receiver systems, parabolic trough systems; Solar power plant; Solar furnaces - Vapor absorption refrigeration cycle; Water, ammonia & lithium bromide-water absorption refrigeration systems; Solar operated refrigeration systems; Solar desiccant cooling. -Solar Thermal Energy Storage - Sensible storage; Latent heat storage; Thermo-chemical storage. Solar still; Solar cooker: Solar Pond.

Solar Passive Building - Thermal comfort; Criteria and various parameters; Calculation of solar radiation on buildings; building orientation; Introduction to design of shading devices; Overhangs; Factors that affect energy use in buildings; Ventilation and its significance; Airconditioning systems; Passive Cooling And Heating Concepts - Passive heating concepts: Direct heat gain, indirect heat gain, isolated gain, and sunspaces; Passive cooling concepts: Evaporative cooling, radiative cooling; Application of wind, water, and earth for cooling; Shading, paints, and cavity walls for cooling; Roof radiation traps; Earth air-tunnel

Net Energy, Intermittency Intensity, Renewable Energy Mix, and Energy Conservation the Potential for Energy Efficiency Subsidies, Environmental Externalities, net metering,

renewable energy pricing

Reference Books:

1. Charles W. Donovan: "Renewable Energy Finance: Powering the Future"
2. Thomas B. Johansson, Henry Kelly, Amulya K.N. Reddy, and Robert H. Williams:
   "Renewable Energy: Sources for Fuels and Electricity
3. William H Kemp, "The Renewable Energy Handbook: A Guide to Rural
   Independence, Off-Grid and Sustainable Living"
4. Lawrence E. Jones, "Renewable Energy Integration: Practical Management of
   Variability, Uncertainty, and Flexibility in Power Grids"
5. B.K.Hodge, Alternative Energy Systems & Applications, Wiley, 2010 J. C. Sabonnadiere, Renewable Energy Technologies, Wiley, 2009,
6. Moselle, Boas, Jorge Padilla, and Richard Schmalensee, eds. Harnessing Renewable Energy in Electric Power Systems RFF Press/Earthscan, 2010.
7. Viscusi, W. Kip, Harrington, Joseph E., Vernon, John M. Economics of Regulation and Antitrust. Fourth Edition, MIT Press, 2005.
8. Keohane, N.O. Olmstead, S. M. Markets and the Environment [Paperback], Island Press.
9. Godfrey Boyle editor Renewable Energy: Power for a Sustainable Future, Second Edition (Paperback), by Oxford University Press 2004
10. Sapan Thapar Policies, Project Management, and Economics: Wind and Solar Power published Springer 2024
11. Gilbert M. Masters (Author), Kevin F. Hsu, Renewable and Efficient Electric Power Systems 3rd Edition published by Wiley 2023

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PE304	Power Systems-II/Electrical Safety/Electric Vehicles	**3L:1T:0P**	**4 Credits**

Power Systems-II

Objectives:	**Learning Outcomes:**
The Instructor will: 1. Provide advanced understanding of operation and performance of various components of the modern power system 2. Give exposure to modelling and control of various aspects of power system	The students are expected to have the ability to: 1. Model and evaluate the performance of a power system 2. Design controllers for various components of power system

Contents:

Power System Performance, Basic concept of active and reactive power control of Synchronous generator. Interdependence of active power with frequency and reactive power with voltage and concept of decoupling.

Speed Governing System: Description of Speed Governor, Speed changer and main components of speed governing system, principle of operation.

Load frequency control: Representation of speed governing system, effect of governor droop on load sharing among generators, dependence of load on frequency, system inertia. Modeling and analysis of single area load-frequency control, supplementary control, concept of control area.

Power system stability: Steady state and transient stability, Swing equation and its numerical solution, equal area criterion for transient stability, improvement of transient stability.

Reactive power control: Role of excitation system, main & pilot exciters, description of different types of excitation systems. Per-Unit representation of Power system– Selection of base quantities, percent and per unit values, advantage of per unit system.

AC Transmission – Power flow through a line, power circle diagram, line charts, active power flow and voltage control in transmission system. Line loadability and voltage dependence.

Power flow in interconnected systems and load flow analysis – Gauss –Seidel method. Symmetrical fault analysis.

Elements of HVDC Power transmission Economic operation of power plant – cost curves, heat rate, incremental rate, economic load sharing among generating units.

Reference Books:

1. Power System Analysis: J. J. Grainger & W. D. Stevension, McGraw Hill
2. Power System Engineering: I. J. Nagrath & D. P. Kothari, Tata McGraw Hill

3. Electric Energy System Theory: O. I. Elgerd, Tata McGraw Hill
4. Elements of Power System Analysis: W. D. Stevenson, McGraw Hill.
5. Power System Analysis: A. R. Bergen & V. Vittal, Pearson Education
6. Power System Analysis Operation and Control: Chakrabarti & Halder, PHI Learning Pvt. Limited.
7. Electrical Power Systems: Ashfaq Husain, CBS Publishers & Distributors Pvt. Ltd.

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Electrical Safety

Pre-requisite Electrical networks, Power systems

Objectives:	**Learning Outcomes:**
To understand the concept of Electrical safety in Low and High Voltage circuits, various Electrical hazards including fire, Concept of Earthing and Various protective devices and strategies,	1. The students will learn the various electrical hazards in Low and High Voltage circuits and various safety equipment 2. The students will be able to understand essential protocols of system earthing and various protection systems and devices to be adopted.

Contents:

Unit 1: Electrical Hazards and Electrical Safety Equipment and Electrical Safety Procedures The Importance of Electrical Safety, Basic Rules of Electrical Safety,Electric Shock, Personal Protective Equipment, Lockout Devices. Electrical Fires and type of fire extinguishers.

Unit 2: Earthing, Earth Faults, and Short Circuits: Basics of Equipment and Sytem Earthing, Types of earthing, Equi-potential bonding, Protection Against Earth Faults in LV circuits, Earth fault loop impedance, Static Electricity Grounding Through Enclosures

Unit 3: Protection against over current in LV circuits and equipment: Protection against Overload currents, Short circuit currents, Current carrying Capacities of conductors, Cable selection. Protection schemes of Motors and transformers.Lightning and surge protection in LV systems

Unit 4: Various protective devices and testing of LV circuits: Isolation, Switching, Control, Protective and Monitoring Devices. Fuses MCBs, MCCBs, RCCBs. Various tests like Continuity, Insulation resistance, Phase sequence etc.

Unit 5: Protection scheme in HT system: Substation and Transmission line protection, Transformer protection, Under frequency Protection for load shedding or Islanding scheme. Various Relays and schemes used for overlapping protection

Reference Books:

1. Safety in Electrical Low Voltage Installations Vol 1 – 8 , CAMTECH RDSO
2. Electrical Safety of Low Voltage Systems by Massimo Mitolo, 1st Edition, 2009 The McGraw-Hill Companies, Inc
3. Power System Protection and Switchgear by Badri Ram and D. N. Vishwakarma 3rd Edition, McGraw-Hill

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Electric Vehicles

Objectives:	**Learning Outcomes:**
To develop understanding of vehicle dynamics calculations for EV system design To develop skills in modeling and simulating power electronics and motor devices for EV systems	1. Student will learn the motor control operation and its role in EV systems. 2. Student will acquire the knowledge to model battery packs and calculate the range for EVs 3. Student will understand the testing requirements for EV systems 4. Students will learn to Analyze and solve simple technical problems using DC applied theory to basic electrical systems while preparing and interpreting electrical schematics in electrified vehicles.

Contents:

ENERGY CONVERSIONS PRINCIPLES: Concept of work power & energy and its unit kinetic and potential energy, Scalar and vector, Torque, Circular and Periodic motion. Concept of Energy, Kinetic and Potential energy, Electrical energy-power-equivalent systems. Energy conversion from mechanical to electrical and vice-versa. Conservation of energy and momentum principles. Dispersion, Equivalent weight, General knowledge, and organic chemistry related to fuels, basic organic chemistry. Analogous systems.

THERMOELECTRICITY AND ELECTROMECHANICAL SYSTEMS: Basics of Electromagnetism, electro-mechanical analogs (flow and static variables, etc.), Introduction to principles of force and torque in motors. Types of motors and uses in the automotive industry are series motors, shunt motors induction motors, and synchronous motors. Seebeck, Peltier, and Thomson effects, measurement of thermos-e.m.f., bimetallic and resistance thermocouple and resistance thermometers. BATTERIES Primary Cells; Dry Cells; types: alkaline cell, Zinc-Carbon cell and many more, etc.; Construction, Working, and Chemical reaction of each of the type; (Secondary Cells: Lead-acid, Ni-Cd, Ni-Fe etc.), Chemical changes during charging and discharging of lead acid batteries. Energy Density, Power Density, Capacity & efficiency of each of the battery especially lead acid battery, care, and maintenance of commercial batteries.

SENSORS: Overview of MEM devices and process. Concepts of MEMs and equations in different domains (electrical-mechanical) Different types of Sensors viz. Pressure, position, temperature, speed, acceleration, ambient light, infrared sensor, gesture, touch screen sensors, etc. The purpose of sensors is to control fuel injection, air mixture, oxygen in the exhaust, speed sensors, infrared sensors for collision and auto parking, ambient light sensors for auto lights, etc., and related systems.

INTRODUCTION TO HYBRID SYSTEMS: Engine Management Systems
(Gasoline/petrol, Diesel, Hybrid), Basics of electronically controlled transmission and all-wheel drive. Concepts of Hybrid Electric Drive Train, Basic Architecture of Hybrid Electric Drive Trains, Types of Hybrid Vehicles, and their benefits.

Books:

1. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electrical, and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
2. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
3. James Larmenie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
4. e- Resources & other digital material 1. https://www.sciencedirect.com/topics/social-sciences/hybrid-electric-vehicle
5. Mehrdad Ehsani - Robert M. Kennedy Endowed Chair of Electrical Engineering & Director of Advanced Vehicle Systems Research Program: Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design published CRC Press.
6. WEI Liu: Hybrid Electric Vehicle System Modeling and Control published by Wiley.
7. Mark Warner: “The Electric Vehicle Conversion Handbook" Published by HP Books
8. Iqbal Husain: Electric and Hybrid Vehicles: Design Fundamentals" published by CRC Press.
9. "The Powerhouse: Inside the Invention of a Battery to Save the World" by Steve by David B. Macpherson: LeVine:

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VLSI Design

PE304	VLSI Design	**3L:0T:0P**	**4 Credits**

Pre-requisite: Analog Electronics

Objectives:	**Learning Outcomes:**
To develop skills for designing and analyzing VLSI circuits and systems. Understanding of nonlinearities present at device and circuit level and their effects on the performance.	1. The students will be able to understand the working of MOSFET in details along with its several nonlinear effects. 2. Students will be able to design simple and complex circuits using MOSFET.

Contents:

1. MOSFET Basics: I-V characteristics of NMOS and PMOS, operating regions and equation for drain current.
2. MOSFET Nonlinearities: Channel length modulation, velocity saturation, mobility degradation, subthreshold conduction, drain induced barrier lowering, gate and junction leakage and temperature induced variations in I-V characteristics.
3. MOSFET Dynamic Behavior: Structure capacitance, oxide and overlap capacitance, channel capacitance, diffusion and depletion capacitance, MOSFET C-V characteristics, frequency effects on C-V characteristics.
4. CMOS Inverter: Static properties, dynamic properties, delay model, power delay optimization, inverter layout design.
5. Combinational circuit design: Static CMOS, ratioed logic, resistive load, active load, differential cascode voltage switch logic, pass transistor logic, differential pass transistor logic.
6. Sequential circuit design: SR latch and flip flop, setup and hold time, propagation delay, 2-phased transparent latch and pulsed latch, maximum and minimum delay constraints, clock skew, time borrowing, static and dynamic timing analysis.
7. Interconnects: Interconnect modeling – lumped capacitor, lumped RC and transmission line model, interconnect delay and crosstalk, interconnect engineering.

Reference Books:

1. Weste, Neil HE, and David Harris. CMOS VLSI design: a circuits and systems perspective. Pearson Education India, 2015.
2. Rabaey, Jan M., Anantha Chandrakasan, and Borivoje Nikolic. Digital integrated circuits. Vol. 2. Englewood Cliffs: Prentice hall, 2002.
3. Razavi, Behzad. Design of analog CMOS integrated circuits, 2005.

Biosensors

PE304	Biosensors	3L:0T:2P	4 Credits

Pre-requisite: Basic understanding of Devices and Biology

Objectives:	Learning Outcomes:
1. To Make the students understand the fundamentals of working principles of biosensors 2. Describe the bio-specific interaction used for various applications 3. Evaluate and compare techniques used in today's time like electric, optical and mechanical 4. Show and explain the examples of practical and real world biosensors	The students are expected to have the ability to: 1. Identify the working mechanism of biosensors 2. Understand the detailed characterization of biosensors in terms of specificity and selectivity 3. Comprehend the functioning of commercial biosensors 4. Create mechanisms for developing biosensors on their own by collaborating or working in an interdisciplinary group

Contents:

1. Introduction to basics of biosensors and biospecific interactions are made
Different components of biosensors, functionalization layers and their importance, Biomolecules for biosensors, catalytic biosensors, affinity biosensors, biomolecular interaction.

2. Electrical and optical techniques for biosensing
Electrical (CV, ISFET), optical (fluorescence, ELISA, SERS, SPR)

3. Electrochemical, mechanical and advanced techniques for biosensing
Electrochemical (sub classifications like impedemetric, voltammetric, amperometric), mechanical (Bio-MEMS), color based, microfluidics (including packaging), AI based biosensors

4. Sensor key parameters and examples of commercially available biosensors
Sensitivity, selectivity, response- and recovery time, LOD etc., Explain and describe few industry standards and commercially available bio-sensors and their functioning. The need and relevance of biosensors in our Indian context.
(*A detailed explanation can be discussed in the lab)

5. Readout Electronics
Basic circuitry to make readout electronics, Potentiostats, amperometric circuits, charge to voltage converter, variable gain amplifier, low noise amplifier, high resolution and low noise data converters, mismatch insensitive data converter

Lab work:

Biosensor fabrication; Biosensor operation and signal generation; Biosensor sensitivity; Biosensor reproducibility; Biosensor Selectivity; Determination of limit of detection; Use of appropriate controls; Biosensor application on real samples.

Reference Books:

1. Yoon J.-Y., (2016), *Introduction to Biosensors*, Springer
2. Banica F.-G., (2012), *Chemical Sensors and Biosensors: Fundamentals and Applications* , Wiley
3. Rasooly A., Herold K. E., (2008), *Biosensors and Biodetection*, Humana Press, Science

Modern Control System/ Multivariable Control

PE304	Modern Control System/ Multivariable Control	**3L:0T:0P**	**3 Credits**

Pre-requisite: Control Systems

Objectives:	**Learning Outcomes:**
The course introduces the fundamental principles of systems represented in state space form. It covers the basics of linear algebra, essential for analyzing linear time-invariant (LTI) systems. Key concepts such as observability, controllability, and stability for linear systems are thoroughly discussed. Additionally, the course addresses essential design problems related to system stabilization, set point tracking, and state estimation.	1 Modelling of LTI system in state space form and determine the state variables and output variable. 2 Deriving the solution of state-space model using matric exponential. 3 Concept of observability and controllability and design state feedback controller and observer. 4 Determine the stability of LTI system using Lyapunov approach.

Contents:

1. Review of control system fundamentals and basic linear algebra.
2. Introduction to linear dynamical systems and properties. State-space representation and canonical realizations, both continuous and discrete time systems
3. Relation between state-space and transfer function representations. Similarity transformation. Diagonalization. Jordan canonical form.
4. Matrix exponential and its properties. Solution of state equations.
5. Concepts of controllability and observability. Minimal realization.
6. State feedback and observer design. Linear Quadratic Regulator.
7. Introduction to Lyapunov stability for LTI systems.

Reference Books:

1. Chen, Chi-Tsong. Linear System Theory and Design. 1999.

2. M Gopal. Digital and State Variable Methods. McGraw Hill Education (India) Pvt Ltd., 2014.

3. Ogata, Katsuhiko. Discrete-time control systems. Prentice-Hall, Inc., 1995.

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Information Theory and Coding

PE304	Information Theory and Coding	**3L:0T:0P**	**3 Credits**

Pre-requisite: Communication Systems

Objectives:	**Learning Outcomes:**
To develop understanding of mathematical principles of communication that govern the compression and transmission of data and the design of efficient methods of doing so	1. Students will have the ability to formulate the fundamental concepts of information theory such as entropy, mutual information, channel capacity. 2. Student will learn the concepts and techniques of modern digital signal processing which are fundamental to all the above applications

Contents:

1. Mathematical definition of information and the study of its properties: Measure of information, entropy, entropy rate, relative entropy, differential entropy, Jensen's inequality, data processing inequality, Fano's inequality.
2. Source coding: Efficient representation of message sources- AEP, Shannon-Fano-Elias, arithmetic coding.
3. Communication channels and their capacity: Mutual information, information channel capacity, Channel coding theorem, Coding for reliable communication over noisy (Gaussian) channels.
4. Gaussian multi-user communications: Parallel Gaussian channels, Multiple access channels, Broadcast channels
5. Rate Distortion Theory: Quantization, Lossy source coding: approximate representation of message sources, calculation of rate distortion function

Reference Books:

1. T. M Cover and J. A. Thomas, Elements of Information Theory, Wiley, 2006.

2. Information Theory and Coding, N Abramson, Mc Graw Hill, 1963, First Edition

3. Digital Signal Processing (Principles, Algorithms, and Applications), John G. Proakis, Dimitria G. Manolakis, Prentice Hall International Inc., 1996, Third Edition.

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Digital Signal Processing

PE304	Digital Signal Processing	**3L:0T:0P**	**3 Credits**

Pre-requisite: Information and Signals

Objectives:	**Learning Outcomes:**
To develop skills for analyzing and synthesizing algorithms and systems that process discrete time signals, with emphasis on realization and implementation	1. Digital signal processing is one of the most important and useful tools an electrical engineer could have. It impacts all modern aspects of life and sciences; from communication, entertainment to health and economics. 2. Student will learn the concepts and techniques of modern digital signal processing which are fundamental to all the above applications

Contents:

1. Sampling and reconstruction, sampling of band-pass signals, The discrete Fourier transform (DFT), Sampling of the discrete time Fourier transform, properties of the DFT, linear convolution using the DFT, Fourier analysis of the signals using the DFT, Direct computation of the DFT, Decimation-in-time FFT algorithms, Decimation-in-frequency FFT algorithm.
2. Design of FIR filters: FIR filters with linear phase, design of FIR filters by windowing and frequency sampling. Design of some special FIR filters, Real Time Implementation of FIR filters.
3. Design of IIR filters: Introduction to IIR filter design, Design of continuous time low pass filters, transformation of continuous time filters to discrete time filters, design examples for low pass IIR filters, Frequency transformations of low pass filters.
4. Multirate signal processing: sampling rate conversion, implementation of Multirate systems, filter design for Multirate systems
5. Finite wordlength effects: Number representation, statistical analysis of quantization error, quantization of Fixed-point and Floating-point numbers, A/D and D/A conversion, A/D conversion noise analysis, quantization of filter coefficients, Effects of finite wordlength on digital filters.
6. Radom signal processing: Spectral analysis of stationary processes, Optimum linear filters, Linear prediction, Forward and Backward linear prediction, Solution of the Normal Equations, Properties of the Linear Prediction-Error Filters, Wiener Filters for Filtering and Prediction and all-pole signal modeling.

Reference Books:

1. Digital Signal Processing, Sanjit K Mitra, Mc Graw Hill, 2008, Third Edition

2. Applied Digital Signal Processing, D. Manolakis and V. Ingle, Cambridge University Press, 2011

3. Digital Signal Processing (Principles, Algorithms, and Applications), John G. Proakis, Dimitria G. Manolakis, Prentice Hall International Inc., 1996, Third Edition.

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Embedded System

PE304	Embedded System	**3L:0T:0P**	**3 Credits**

Pre-requisite: Digital Electronics, Microprocesors and Microcontrollers

Objectives:	**Learning Outcomes:**
The Instructor will: 1. Introduce concepts of different architectures and programming languages of embedded processors. 2. Introduce concepts of Real time system and design of embedded systems	The students are expected to have the ability to: 1. Program and to design embedded system using embedded processors based on system specifications. 2. Use different IDE and debugging tools.

Contents:

Contents Architecture of ARM Cortex M3 and Cortex A series processors;

Introduction to Embedded Multicore Architecture; Multicore Processor Design Technique; Interconnection networks for Multicore Processors;

Programmable Systems on Chip; Architecture of DSPs; Fixed and Floating point devices; Security at Hardware level

Selection of DSP chips; Performance assessment of embedded processor

Programming of Embedded processors using assembly and C;

Models for program --data flow graphs; Programming of multicore processors; Assembly language programming of ARM Cortex M3;

Hardware software co-design;

Processes and real time operating systems; Multi-rate system;

Real time scheduling algorithms e.g. RMA, EDF and their variants;

Energy efficient scheduling algorithms; Structure of Real Time operating system; Overhead of RTOS;

Example of Real time operating systems e.g. real time Linux, Keil RTX Real-Time Operating System, programming of embedded processors with RTOS

Reference Books

1. Wolf, M., (2014), High Performance embedded Computing: Applications in Cyber Physical Systems and Mobile Computing, Elsevier
2. Josheph Yiu, (2013), The definitive Guide to ARM Cortex M3 and M4 Processors, Elsevier.
3. Buttazzo, G., (2011), Hard Real-Time Computing Systems: Predictable Scheduling Algorithms and applications, Springer
4. Wolf, M., (2012) Computers as Components: Principles of Embedded Computing System Design, Third Edition, Elsevier

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Introduction to Robotics and Automation

PE303/PC302	Introduction to Robotics and Automation	**3L:1T:2P**	**5 Credits**

Objectives:	**Learning Outcomes:**
This course offers a comprehensive introduction to robotics and automation, covering essential components, theoretical foundations, coordinate transformation, D-H parameters, kinematics, velocity kinematics, singularity analysis, trajectory planning, robot control strategies, actuator and sensor integration, vision-based robotic control, and mobile robot modeling.	1. Apply coordinate transformations and D-H parameters to solve kinematics problems. 2. Analyze velocity kinematics using the Jacobian and identify singularities. 3. Understand and model the dynamics of holonomic and non-holonomic robotic systems. 4. Design and implement control strategies, including linear and nonlinear approaches, for various robotic applications.

Contents:

1. Introduction to robotics. Basic components of robotic systems.
2. Coordinate Transformation, D-H parameters. Forward and inverse kinematics.
3. Velocity kinematics and Jacobian, Singularity analysis.
4. Robot Dynamics: Holonomic and Non-Holonomic Systems.
5. Trajectory planning. Robot control: linear and nonlinear. Actuators and Sensors.
6. Vision based Robotic Control. Mobile Robots: Modeling and Control.

Reference Books:

1. Mark W. Spong, Seth Huchinson and M. Vidyasagar, "Robot Modeling and Control", John Wiley and Sons, Inc.

SEMESTER – VII

Semester – VII

Power System Optimization

OE401	Power System Optimization	**3L:0T:0P**	**3 Credits**

Pre-requisite

Contents:

Basics of optimization: Short-term system operation – Economic dispatch – Power flow and optimal power flow DC OPF, AC OPF – Unit commitment – Security-constrained unit commitment – Ancillary services , Reactive power procurement and voltage security , multi-objective optimization and Pareto optimality

Power Flow: Models and numerical methods – Cascading failures, Convex Optimization – Convex sets and functions – Weak and strong duality, Optimization of Power Flow – Convex approximations and relaxations, Renewable Energy Integration – Models of uncertainty – The role of stochastic optimization, Electricity Markets – Market design – Learning, strategic behavior, and market equilibria.

Special Topics: Power System Economics Basic pricing principles, Supply-side and demand-side options, Load management and spot pricing, Electricity pricing, charging for transmission and distribution services, Cost of generating electrical energy Methods of determining depreciation, Importance of high load factor Markets and monopolies, Electricity market structure, Market clearing, social welfare functions for pricing.

Reference Books:

1. Taylor, Joshua. Convex Optimization of Power Systems. Cambridge University Press, 2015.
2. Boyd, Stephen P., and Lieven Vandenberghe. Convex optimization. Cambridge University Press, 2004
3. Glover, J. Duncan, Mulukutla S. Sarma, and Thomas J. Overbye. Power system analysis and design. CengageBrain.com, Fifth Edition. 2012. 2.
4. Wood, Allen J., Bruce F. Wollenberg, and Gerald B. Sheble, Power generation, operation, and control. John Wiley & Sons, Third Edition. 2014.

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DSP Based Control of Drives

DEL	DSP Based Control of Drives	**3L:0T:0P**	**3 Credits**

Pre-requisite: Electrical Machines-I, Power electronics

Objectives:	**Learning Outcomes:**
The Instructor will: Provide understanding of DSP based control of electrical drives	The students are expected to have the ability to: Use DSP controllers for control of electric drives

Contents:

Introduction and Application of DSP in the power electronic converter controlled drives, Types of processors used for power control and their comparison, computational advantages, Limitations. Introduction to peripherals ADC, DAC, PWM, Encoders and their interface. Interfacing issues, Sampling process, Harmonic analysis in real-time using a DSP, Assembly language programming of a DSP, Motor control applications. Pulse-Width Modulation and Pulse-Frequency Modulation schemes, lookup tables and real-time computation. Interfacing and signal conditioning circuits for DSP based schemes. Realization of computationally intensive algorithms like variable structure, adaptive and neural network schemes for Drives systems.

Reference Books:

1. Slobodan N. Vukosavic, Digital Control of Electric Drives, Springer, 2007.

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Power Systems Protection

DEL	Power Systems Protection	**3L:0T:0P**	**3 Credits**

Objectives:	**Learning Outcomes:**
To develop understanding of the cha and solutions for the power protection problems	1. Student will learn to analyze power system faults for balanced and unbalanced conditions. 2. Student will acquire the knowledge to identify signal processing techniques needed for power system protection.

Course Content

Introduction to the Course: Need for Protective Systems, Nature and Causes of Faults, Types of Faults, Effects of Faults, Fault Statistics, Evolution of Protective Relays, Zones of Protection Primary and Back-up Protection Essential Qualities of Protection, Performance of Protective Relays, Classification of Protective Relays, Components of a Protection System, Classification of Protective Schemes, Automatic Reclosing, Current Transformers (CTs) for Protection, Voltage Transformers (VTs), Basic Relay Terminology, Role of relaying theory, Field experiences

Distribution Protection - Overcurrent Protection: Principles of overcurrent and undervoltage schemes, Neutral grounding, Fuses, Overcurrent relays, Circuit reclosers, and Impact of power electronic converter sources.

Non-Pilot Line Protection of Transmission Lines: Relay setting philosophy, 3-terminal lines,

Pilot Line Protection of Transmission Lines: Communication channels, Directional comparison. transfer trip, Phase comparison, Wire pilot, Settings,

Bus and Transformer Protection: Bus arrangements, Zone interlocking protection, Bus partial and full differential protection, Magnetizing inrush, Transformer protection, load shedding

Artificial Intelligence Based Protection: Basics of Artificial Neural Network (ANN), Fuzzy Logic, Application of ANN to Overcurrent Protection, Application of ANN to Transmission Line Protection, Neural Network Based Directional Relay, ANN Modular Approach for Fault Detection, Classification and Location Application of ANN and Fuzzy logic to Power Transformer.

Circuit Breakers: Functions of switchgear, arc extinction, arc control devices, recovery voltage, and restriking voltage, current chopping and capacitance current breaking, bulk

oil, low oil, air brake, air blast, and sulfur hexafluoride and vacuum circuit breakers, HVDC breakers, rating, testing of circuit breakers.

Surge Protection: Switching surges, lightning phenomenon, traveling waves on transmission lines, over-voltage due to lightning, protection against lightning, lightning arresters, lightning arrester selection, surge absorbers.

Earthing and Insulation Co-Ordination: Solid resistance and reactance earthing, arc suppression coil, earthing transformers, earth wires, earthing of appliances, insulation coordination: determination of line insulation, insulation levels of sub-station equipment, coordination amongst items of substation equipment, introduction to Indian electricity rules.

Reference Books:

1. Fundamentals of Power System Protection: By Y.G. Paithankar published by Prentice Hall India
2. Power System Protection and Switchgear 3rd Edition, By D N. Vishwakarma, Badri Ram, Soumya R Mohanty published by Tata McGraw-Hill India
3. Network Protection & Automation Guide: By Alstom
4. Digital Protection: By L. P. Singh published by New Age International Publisher
5. Digital Power System Protection: By R. P. Singh JAICO PUBLISHERS SINGH CBS publishers
6. Power System Protection: Fundamentals and Applications, Aaron Cooperberg, John Ciufo published Wiley
7. Power System Protection: By Wiley-IEEE Press

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Advanced Electromechanics

DEL	Advanced Electromechanics	**3L:0T:0P**	**3 Credits**

Prerequisite: Basic Electrical Engineering

Objectives	**Learning Outcomes**
1. Ability to analyse/design electromagnetic circuits/devices. 2. Understanding of the concepts and principles of electromagnetic energy conversion 3. Understanding of the concept of time-varying transformations in the analysis of time-varying systems, 4. Ability to analyse brushless dc machine 5. Ability to analyse induction machines	1. The students are expected to have an ability to model and design electromechanical Systems

Contents:

Electromechanical Concepts

Magnetic and Coupled Circuits, Energy Conversion, Stepper motors,DC Machines, DC/DC power converters, Rotating MMF concepts], Introduction to Brushless DC motors, Transformers, Induction machines.

Electromechanical System Analysis

Single phase Induction Motor Analysis, Modelling of single-phase induction motor Generalized rotating field Theory, Analysis of Asymmetrical Machines Generalized Rotating Field Theory.

Electromechanical Machines

Variable reluctance(VR) Motors, Switched Reluctance Motor, Induction Generators, Self-Excited Induction generator, Permanent Magnet machines (BLDC motor study)

Reference Books:

1. Robert Wald, (2022) *Advanced Classical Electromagnetism* , Princeton University Press
2. Paul Krause, Oleg Wasynczuk, Steven Pekarek (2012)- Electromechanical Motion Devices, Second Edition-Wiley-IEEE Press

Online Course Material:

1. https://nptel.ac.in/courses/108102156https://engineering.purdue.edu/online/courses/electromechanics

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Operating Systems

DEL	Operating Systems	**3L:0T:0P**	**3 Credits**

Pre-requisite Computer Organization and Architecture

Objectives:	**Learning Outcomes:**
1. To develop understanding about the importance of the operating system and its function. The different techniques of the operating system to achieve its goals as resource manager. Application interaction with the operating system and the operating systems interaction with the machine.	1. Operating Systems is one of core topics to get understanding of user interaction with the hardware. 2. The course enhances the learning of application interaction with the operating system as it works as intermediary program between the machine and the application. 3. The way operating systems transport the application requests to the hardware, managing resources such as processors, memory and I/O.

Contents:

Introduction and history of Operating systems: - structure and operations; processes and files; Computer system organization (Computer Hardware) consists of Device, Device controller, Interrupt, Device and CPU interaction, Bootstrap program.

I/O structure: Polling, interrupt, and DMA, resolve interrupt through interrupt vector, Computer System Architecture, Single Processor System, Multiple Processors System, advantages of using multiple processor system, Operating System Structure and Operations, Dual Modes operation, Timer, Process management, Storage management.

Processes: Processor management: inter process communication, mutual exclusion, semaphores, wait and signal procedures, process scheduling and algorithms, critical sections, threads, multithreading; Process concept, PCB, Process state, Process scheduling (long, medium- and short-term schedulers), Process operations, Interprocess communication, Techniques of Intercrosses communication, Message passing, Shared memory, Client server

CPU scheduling: Preemptive and non-preemptive scheduling, scheduling criteria, algorithms: FCFS, SJF, Prediction of next burst of SJF, Priority Scheduling, Round Robin, Multilevel Queues, Multilevel feedback. Process Synchronization: Introduction and background, Critical section (C.S.) problem, Condition for the solutions of C.S., Algorithms: Peterson, Hardware solutions, Semaphores, Monitors.

Main Memory Management :-Memory management: contiguous memory allocation, Basic Hardware for managing Memory, Address binding, Contiguous allocation (based on fixed and variable partitions), Relocation and protection problems, Fragmentation, Non-contiguous allocation. Virtual memory, paging, paging hardware support page table structure, demand paging, page replacement policies, thrashing, Segmentation, Paging with Segmentation.

Deadlock: Shared resources, resource allocation and scheduling, resource graph models, deadlock detection, deadlock avoidance, deadlock prevention algorithms

Device management - devices and their characteristics, device drivers, device handling, disk scheduling algorithms and policies

File management: file concept, types and structures, directory structure, cases studies, access methods and matrices, file security, user authentication; File Systems: -File system structure, Implementation, Partition and mounting, Allocation methods: Contiguous, Linked, Indexed Free space Management: Bit vector, Linked list

Case Studies: UNIX and Linux operating systems as case studies; Mobile OS

Reference Books:

1. A. Silberschatz & P.B. Galvin, Operating System concepts and principles', Wiley India.
2. A. Tanenbaum, Modern Operating Systems', Prentice Hall India
3. W. Stallings,_Operating Systems: Internals and design Principles', Pearson Ed.,
4. M.J. Bach, Design of Unix Operating system', Prentice Hall,

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Robotics and Automation

DEL	Robotics and Automation	**3L:0T:0P**	**3 Credits**

Pre-requisite: Basic mechanics

Objectives:	**Learning Outcomes:**
To introduce fundamental aspects of modelling and control of robot manipulators and provide a brief of results from geometry, kinematics, dynamics, motion planning and control	1. Robotics is one of the emerging and useful areas for an electrical engineer. 2. The course will equip students with theoretical and practical knowledge of robot modelling, control and programming.

Contents:

1. Introduction and Position Kinematics: Types of Robots and applications, Serial Robots, Transformations, Rigid Motions, Forward Kinematics: Denavit-Hartenberg Convention, Inverse Kinematics.
2. Velocity Kinematics – The Jacobian: Angular and Linear Velocity: Singularities, Accelerations.
3. Robot Dynamics: Equations of Motion, Kinetic and Potential Energy, Euler-Lagrange Equations, Recursive Newton-Euler Formulation.
4. Path and Trajectory Planning: Path vs. Trajectory, The Configuration Space, Path Planning in Configuration Space, Probabilistic Roadmap Planner, Potential Fields, Trajectory Planning, Point To Point Motion, Paths Specified by Via Points,
5. Sensors and Actuators: Joint Actuating Systems, Drives, Proprioceptive Sensors, Exteroceptive Sensors
6. Control: Modelling Robot joint as a Second-order linear system, Control-law partitioning, trajectory-following control, disturbance rejection, Nonlinear and time-varying systems, multi-input, multi-output control systems, control of manipulators, practical considerations
7. Robot Operating System (ROS): Basic ROS concepts, Writing RoS Programs, Log Messages, Graph Resource Name, Launch Files, Parameters, Services, Recording and Replaying Services

Reference Books:

1. Introduction to robotics, Saha S. K., Tata McGraw-Hill Education, 2017, Second Edition.

2. Robotics: fundamental concepts and analysis, Ghosal, A., Oxford University Press, 2006

3. Introduction to robotics: mechanics and control. Craig J. J, Pearson/Prentice Hall, 2022, Fourth edition

4. Robot modelling and control. Spong M. W., Hutchinson S., and Vidyasagar M., New York: Wiley, 2020.

5. Modelling and control of robot manipulators. Sciavicco, L. and Siciliano, B., 2012. Springer Science & Business Media, 2001

6. A Gentle Introduction to ROS O'Kane J. M., CreateSpace Independent Publishing Platform, 2013.

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Machine Intelligence and Learning

DEL	Machine Intelligence and Learning	**3L:0T:0P**	**3 Credits**

Pre-requisite

Objectives:	**Learning Outcomes:**
To develop understanding of Machine learning algorithms with their associated mathematical foundations	1. Student will learn to implement basic algorithms using basic machine learning libraries mostly in Python 2. Student will learn to connect real-world problems to appropriate ML algorithm(s) for solving them.

Machine Learning:

Deep Learning: methods that perform machine learning through multilayer neural networks of various kinds: Supervised Learning, Unsupervised Learning, and Reinforcement Learning.

Recurrent Neural Networks - adding links to past timesteps, learning with the memory of the past 9 Convolutional Neural Networks - adding convolutional filters,

Statistical Concepts mean, mode, max, min - basic statistics and patterns & prediction/regression - least squares, ridge regression, linear classification - use distances and separation of data points. (logistic regression, State Vector Machine, KNN (k-nearest neighbors (KNN))

Kernel-Based Classification - define a mapping from original data to a new space.

Decision trees - learn rules that divide data arbitrarily (C4.5, Random Forests, AdaBoost)

References Books:

1. Goodfellow, Bengio, and Courville. “Deep Learning”, MIT Press, 2016. http://www.deeplearningbook.org/ Website has free copy of the book as pdfs.
2. Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012.
3. R. O. Duda, P. E. Hart and D. G. Stork, Pattern Classification (2nd ed.), John Wiley and Sons, 2001. Mark Crowley A to Z of AI/ML Sep 23, 2017.
4. Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, Mathematics for Machine Learning, Cambridge University Press (23 April 2020)
5. Tom M. Mitchell- Machine Learning - McGraw Hill Education, International Edition
6. Aurélien Géron Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, O'Reilly Media, Inc. 2nd Edition
7. Christopher M. Bishop Pattern Recognition and Machine Learning - Springer, 2nd edition
8. Trevor Hastie, Robert Tibshirani, and Jerome Friedman - The Elements of Statistical Learning: Data Mining, Inference, and Prediction - Springer, 2nd edition

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Multicore Systems

DEL	Multicore Systems	**3L:0T:0P**	**3 Credits**

Pre-requisite: Computer Organization and Architecture

Objectives:	**Learning Outcomes:**
There has been a radical shift in computers in recent years. Almost all computers are now multicore. Since the speed of individual sequential processor is not increasing, the only way to improve performance for applications is to harness the multiple cores. This course will introduce the students to the world of multi-core computer architectures. With the unprecedented growth of data science, on-chip storage systems and inter-core communication framework are getting equal attention as that of processors. This course will focus on delivering an in-depth exposure in memory-subsystems and interconnects of Tiled Chip Multi-Core Processors and superscalar processors.	1. Identify the limitations of Instruction Level Parallelism (ILP) and the need for multicore architectures 2. Solve the issues related to multiprocessing and suggest solutions 3. Make out the salient features of different multicore architectures and how they exploit parallelism

Contents:

Basic Computer Organization: Review of Basic Computer Organization, Basic operational concepts, fundamental of program execution, memory and I/O addressing, Instruction set architecture- addressing modes, instruction set, instruction encoding and formats. CISC vs RISC ISA.

Instruction Pipeline Principles: Performance Evaluation Methods, Introduction to RISC Instruction Pipeline, Instruction Pipeline and Performance. Pipeline Hazards and Analysis Multi-Cycle Operations.

Multi-Core Processors: Single core to Multi-core architectures, Single-Core Processor, Multi-core processor, MIMD systems, Interconnection networks, Shared-memory interconnects, Distributed-memory interconnects, Performance Issues; Speedup and efficiency, Amdahl's law, Scalability, Parallel program design

Pipeline Scheduling and Speculative execution: Compiler Techniques to Explore Instruction Level Parallelism, Dynamic Scheduling with Tomasulo's Algorithm, Speculative Execution.

Superscalar Processors and GPU architectures: Advanced Pipelining, Multithreading and Hyperthreading, Superscalar Processors, GPU Architectures.

Cache Memory Optimizations: Design issues for improving memory access time, Basic and Advanced Optimization Techniques in Cache Memory

Cache Coherence Protocols: Cache coherence and memory consistency, Snoop Based and Directory Based Cache coherence Protocols.

Tiled Chip Multi-Core Processors & Network-on-Chip: Tiled Chip Multicore Processors (TCMP), Network on Chips (NoC), Routing Algorithms, NoC router – architecture, Routing and flow control

Energy Efficient NoCs: Introduction to deflection routing, Energy Efficient Buffer-less NoC Routers, Side-buffered Deflection Routers

Books and references

1. John L. Hennessy, David A. Patterson, “Computer Architecture - A Quantitative Approach,” 5th Edition, Morgan Kaufman.

2. Bruce Jacob, Spencer W. Ng, David T. Wang, “Memory System - Cache, DRAM and Disks,” Morgan Kaufman.

3. William J. Dally, Brian P. Towles, “Principles and Practices of Interconnection Networks,” Elsevier.

4. Yan Solihin, "Fundamentals of Parallel Multicore Architecture", 1st Edition, CRC Press/Taylor and Francis.

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Renewable Energy System

DEL	Renewable Energy System	**3L:0T:0P**	**3 Credits**

Pre-requisite:Physics and Chemistry

Objectives:	**Learning Outcomes:**
To develop understanding of the technology and characteristics of power electronic converters and electrical machines for the interfacing of energy systems.	1. Student will learn to Select appropriate technology and configurations for clean energy systems. 2. Identify high-efficiency end-user systems Student will acquire the knowledge to apply methods to construct and evaluate the performance of integrated energy conversion systems.

Contents:

1. **Energy Scenario:** Classification of Energy Sources, Energy resources (Conventional and nonconventional), Energy needs of India, and energy consumption patterns. Worldwide Potentials of these sources. Energy efficiency and energy security. Energy and its environmental impacts, Distributed generation. Solar Energy: Solar thermal Systems: Types of collectors, Collection systems, efficiency calculations, applications.

2. **Solar Photo Voltaic:** Photovoltaic (PV) technology: Present status, solar cells, cell technologies, characteristics of PV systems, equivalent circuit, array design, building integrated PV system, its components, sizing, and economics. Peak power operation. Standalone and grid interactive systems.
3. Wind Energy: Wind speed and power relation, the power extracted from wind, wind distribution, and wind speed predictions. Wind power systems: system components, Types of Turbines, Turbine rating. Choice of generators, turbine rating, electrical load matching, Variable speed operation, maximum power operation, control systems, system design features, stand-alone and grid-connected operation. Small Hydro Systems

4. **Biomass and Biofuels.** Gasifier, down draft, updraft, and cross draft gasifiers, problems of tar, and remedies. Briquetting, Chemical Analysis of Briquettes, Briquettes as part fuel along with routine fuel in gasifiers. Bio-Gas- Type of Plants, operation, Generation of Electricity from biogas, maintenance and designing of the plant.

5. **New energy technologies:** Tidal and geothermal energy, GSHP: ground source heat pumps for air conditioning, misting for cooling, Fuel Cells.

6. **Grid Integration:** Stand-alone systems, Concept of Micro-Grid and its components, Hybrid systems – a hybrid with diesel, with fuel cell, solar-wind, wind–hydro systems, mode controller, load sharing, system sizing. Hybrid system economics, Interface requirements, Stable operation, transient safety,

Operating limits of voltage, frequency, stability margin, energy storage, and load scheduling. Social and environmental aspects.

7. **Energy storage and hybrid system configurations:** Energy storage, Battery – types, equivalent circuit, performance characteristics, battery design, charging, and charge regulators. Battery management. Flywheel-energy relations, components, benefits over battery. Fuel Cell energy storage systems. Ultra-Capacitors.
8. **Power Electronic Converters:** Three main classes of power electronic converters (AC/AC, DC/DC, AC/DC); components, operational principles and steady-state characteristics, limitations, efficiency, control of systems; system modeling.
9. Energy Interfacing: Interfacing to renewable energy sources; interfacing to cleaner technologies; full-system energy flows to/from supply and to/from loads; selection of technologies and configurations; system modeling and control; case studies of energy efficiency enhancement; energy storage, system reliability, and condition monitoring.

SUGGESTED READINGS:

1. Renewable energy technologies - R. Ramesh, Narosa Publication.
2. Energy Technology – S. Rao, Parulkar
3. Non-conventional Energy Systems – Mittal, Wheelers Publication.
4. Non-Conventional Sources of Energy- G.D.Rai, Khanna Publishers
5. Non-Conventional Sources of Energy- B. H. Khan, TMH Publication
6. Renewable Energy sources And Emerging Technologies, DP. Kothari, PHI.
7. Hand Book of Renewable Energy Technology, Ahmed F Zooba, R C Bansal World scientific.

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Digital Control

DEL	Digital Control	**3L:0T:0P**	**3 Credits**

Pre-requisite: Modern Control Syste

Objectives:	**Learning Outcomes:**
The course aims to introduce the fundamental concepts, principles, and applications of digital control system analysis and design, providing deeper insights into various aspects of digital control engineering. The topics encompass both classical control design methods and modern control design techniques of digital control.	1. Develop discrete-time mathematical for real time process/plants in the discrete time framework. 2. Analyze the stability for the discrete time system and determine the steady state behavior. 3. Determine the controllability and observability for the system and solve state estimation problem using discrete-time observers. 4. Design of dead beat control and feedback controllers for stabilization and set-point tracking.

Contents:

1. Introduction to digital control, discrete time system representation, mathematical modelling of sampling process, data reconstruction, Z-transform, Mapping of s-plane to z-plane, Pulse transfer function, Pulse transfer function of closed loop system.
2. Stability analysis of discrete time systems Jury stability test Stability analysis using bi-linear transformation. Transient and steady state responses Time response parameters of a prototype second order system.
3. Design of digital control systems with deadbeat response, Practical issues with deadbeat response design, Sampled data control systems with deadbeat response.
4. Discrete state space model, Introduction to state variable model, Various canonical forms, Characteristic equation, state transition matrix, Solution to discrete state, equation.
5. Controllability, observability and stability of discrete state space models
6. Lyapunov stability theorem for discrete time systems.
7. State feedback design, Pole placement by state feedback, Set Point Tracking Controller, Full order observer, Reduced order observer.

Reference Books:

1. K. Ogata, Discrete Time Control Systems, Prentice Hall, 2/e, 1995.
2. M. Gopal, Digital Control and State Variable Methods, Tata Mcgraw Hill, 2/e, 2003.
3. B. C. Kuo, Digital Control Systems, Oxford University Press, 2/e, Indian Edition, 2007.

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Power System Dynamics and Control

DEL	Power System Dynamics and Control	**3L:0T:0P**	**3 Credits**

Pre-requisite

Objectives:	**Learning Outcomes:**
To develop understanding of the fundamental dynamic behavior of power systems to perform basic stability issues.	1. Student will Acquire the fundamental knowledge about the modeling of synchronous machines 2. Student will understand the general stability concepts and analysis methods and their specific applications in power system stability analysis and control.

Contents

Power system stability: Introduction to power system stability problems, and analysis of stability in single and multi-machine systems

Modeling: Dynamic model of the synchronous machine. Synchronous machine primary and secondary controls include automatic voltage regulators, turbine, and turbine governors, under and over-excitation limiters, and power system stabilizers. Voltage control, transient stability control, dynamic stability control, and Modeling, Modeling of power system components, such as generators, transmission lines, excitation, and prime mover controllers, Synchronous machine secondary controls including automatic generator controllers and secondary voltage regulators. Tertiary frequency control Transformer dynamic model and controllers including under-load tap-changers and phase shifters.

Control: Secondary control principles, including setpoint control of active power and voltage, active reserves, and load following control.

Stability analysis: Transient stability, small signal stability, and voltage stability, Power system control and emergency control VSC model and controls. Control of shunt and series FACTS devices. Distributed energy sources control with particular emphasis on models and controllers of wind turbines and photovoltaic panels (MPPT, voltage control, frequency control.

1. K. R. Padiyar, “Power System Dynamics, Stability & Control”, BS Publications, Hyderabad - 500 095 - AP., Second Edition, 2008.
2. P. Kundur, “Power system stability and control”, McGraw Hill Inc, New York, 1995.
3. P.M. Anderson and A. A. Fouad, “Power System Control and Stability”, Galgotia Publications, New Delhi, 2003 or P.M. Anderson and A. A. Fouad, “Power system control and stability”, IEEE Press
4. R. Ramanujam, “Power Systems Dynamics”- PHI Publications.
5. M. A. Pai and W. Sauer, “Power System Dynamics and Stability”, Pearson Education Asia, India, 2002.
6. I.J. Nagrath, D.P. Kothari, “Modern Power System Analysis”, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1994.

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Optimal Control Theory

DEL	Optimal Control Theory	**3L:0T:0P**	**3 Credits**

Pre-requisite: Modern Control System

Objectives:	**Learning Outcomes:**
This course offers a comprehensive introduction to optimal control theory and its applications. Students will learn to maximize functionals using calculus of variations, address constrained extremals with the Euler-Lagrange equation, and apply Pontryagin's minimum principle. Key topics include minimum time and control effort problems, the linear quadratic regulator, Riccati equation, and the principle of optimality. The course also covers dynamic programming for routing and optimal control, the Hamilton-Jacobi-Bellman equation, and numerical techniques for determining optimal trajectories.	1. Maximize functionals using calculus of variations and solve constrained optimization problems with the Euler-Lagrange equation and Pontryagin's minimum principle. 2. Address minimum time, minimum control effort, and linear quadratic regulator problems, and use the Riccati equation. 3. Apply the principle of optimality and dynamic programming to decision-making and routing problems. 4. Use numerical techniques to determine optimal trajectories in control systems.

Contents:

1. Maximization of functionals of a single and several functions using calculus of variations.
2. Constrained extremals, Euler-Lagrange Equation, Necessary conditions for optimal control, Pontryagin's minimum principle and state inequality constraints.
3. Minimum time problems, Minimum control effort problems, Linear quadratic regulator problems, Riccati Equation, Singular intervals in optimal control problems.
4. The principle of optimality, Application of the principle of optimality to decision making.
5. Dynamic programming applied to routing problems, Solving optimal control problems using dynamic programming.
6. Discrete linear regulator problem, Hamilton -Jacobi -Bellman Equation.
7. Numerical Techniques to determine optimal control.

Reference Books:

1. Lewis FL, Vrabie D, Syrmos VL. Optimal control. John Wiley & Sons; 2012 Mar 20.

2. Naidu, D.S., 2018. Constrained optimal control systems. In Optimal control systems (pp. 293-364). CRC press.

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Digital Image Processing

DEL	Digital Image Processing	**3L:0T:0P**	**3 Credits**

Pre-requisite: Information and Signals

Objectives:	**Learning Outcomes:**
1. To develop skills for analyzing and synthesizing algorithms processing of images to extract the relevant properties for desired applications.	1. Student will learn the concepts and techniques to analyze the image data with respect to perception, storage and feature extraction.

Contents:

1. Basic Preliminaries: Linear system and shift invariance, 2D Fourier transform, random signals, orthogonal and unitary matrices, eigen decomposition, principal component analysis, singular value decomposition.
2. Image perception and representation: Human visual system, light, luminance and contrast, color and monochrome perception, bit-plane representation, noise, linear and non-linear color spaces.
3. Image Enhancement: point operations, histogram modelling, spatial operations, frequency domain operations.
4. Image Filtering: Fourier domain filters, Wiener filtering, homomorphic filtering, least square, spatial domain filters: Gradient, Laplacian.
5. Image Analysis and Computer Vision: corner detection, edge detection, boundary extraction and representation, structure and moment representation. image segmentation, image classification.
6. Image Compression: pixel coding, predictive techniques, transform coding, JPEG compression.

Reference Books:

1. Fundamentals of Digital Image Processing, A. K. Jain, Prentice Hall
2. Digital Image Processing, Rafael C. Gonzalez and Richard E. Woods, Pearson Education India, 2018, Fourth Edition.

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Multirate Digital Signal Processing

DEL	Multirate Digital Signal Processing	**3L:0T:0P**	**3 Credits**

Objective	**Learning Outcomes**
To develop the concept of multirate signal processing and demonstrate the ability to solve the problems in sample rate conversion, filter banks and Transmultiplexers	1. Capability to understand the basic concepts of multirate systems; understanding of decimation, interpolation and filterbanks 2. Ability to understand the realizations for upsampling and downsampling of signals using polyphaser decomposition 3. The ability to design the filter banks based on the techniques discussed in the class.

Course Content

1. **Introduction to Multirate DSP:** Sampling and Nyquist Criterion, Signal Reconstruction, Reconstruction Filter

2. **Multirate DSP Blocks:** Upsampling, Interpolation, Decimation, Fractional Sampling rate operations, Multiplexer/demultiplexer interpolation, Noble Identities and Polyphae Decomposition

3. **Filterbanks:** Introduction to multirate filter banks, Applications of Multirate, DFT and High Resolution Spectral Analysis, Transmultiplexers and Maximally Decimated Filterbanks, Two-channel filter bank, 2-channel QMF filter design, All Pass Filters, Perfect reconstruction filterbanks, Introduction to OFDM, Multirate DSP framework for Multi-carrier Modulation, M-channel Multicarrier Transceiver

4. **Applications of Multirate DSP:** Delta-Sigma A/D, wavelets, and multirate filterbanks

Reference Books

1. Oppenheim AV & Schafer RW, Discrete Time Signal Processing, PHI
2. Proakis JG and Manolakis DG, Digital Signal Processing Principles, Algorithms and Applications, PHI.
3. Vaidyanathan P P, Multirate Systems and Filter Banks, Pearson Education, 2008.
4. Fredric J Harris, Multirate Signal Processing for Communication Systems, 1st Edition, Pearson Education, 2007

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Smart Grid Technology

DEL	Smart Grid Technology	**3L:0T:0P**	**3 Credits**

Objectives:	**Learning Outcomes:**
The objective of the Smart Grid Technology course is to provide students with a comprehensive understanding of the principles, technologies, and applications related to modern electrical power systems, with a focus on smart grid technologies.	1. By the end of this course, students will possess a deep understanding of the evolution, objectives, and main features of smart grids. They will be able to analyze key technology areas and challenges associated with smart grid implementation. 2. Students will be able to analyse key technology areas and challenges, evaluate energy resources, including renewable energy integration, and grasp demand-side management techniques such as load profiling, pricing dynamics, and forecasting, considering relevant regulations. 3. Students will also gain proficiency in smart grid communication, monitoring, and protection mechanisms, including cybersecurity and privacy considerations. 4. Finally, students will be able to comprehend the integration of Plug-in Electric Vehicles (PEVs) with the grid, understanding infrastructure challenges and leveraging PEVs as energy storage solutions. 5. Through practical applications and case studies, students will be equipped with the skills and knowledge necessary to contribute effectively to the advancement and implementation of smart grid technology in real-world scenarios.

Contents:

1. Smart Grid Basics: Evolution of electric power grid and smart grid, objectives and main features. Key technology areas and challenges of smart grid (4 Lectures)

2. Energy Resources: Centralized vs. distributed generation; renewable energy: solar, wind, hydropower, biomass, geothermal, ocean wave; benefit, costs, and policies of renewable energy; renewable sources integration – overcoming intermittence; storage systems technology (9 Lectures)

3. Demand-side Management: Load profile of the power grid; market pricing; peak shaving and valley filling; load forecasting; regulations and policies. (9 Lectures)

4. Smart Grid Communication: Two-way digital communication paradigm, network architectures, IP-based systems, power line communications, advanced metering infrastructure (AMI). (7 Lectures)

5. Monitoring and Protection: Sensor networks, wide area measurement, systems (WAMS), , phasor measurement units (PMUs), communications infrastructure, fault detection and self-healing systems, application and challenges; Security and Privacy: cyber security challenges in smart grid, defense mechanism, privacy challenges. (9 Lectures)

6. Plug-in Electric Vehicle (PEV): EV and electric power grid; PEV charging infrastructure, challenges and solutions; PEV as an energy storage device and an energy source (V2G). (4 Hours)

Reference Books:

1. James Momoh *'Smart Grid: Fundamentals of Design and Analysis'* Wiley-IEEE Press, 2012.
2. Phillip F. Schewe *'The Grid: A Journey through the Heart of our Electrified World'* Joseph Henry Press, 2006.
3. J. Duncan Glover, Mulukutla S. Sarma, and Thomas J. Overbye, *Power System Analysis and Design*, 4th Ed.,Stamford, CT: Cengage Learning, 2008.
4. Jan Machowski, JanuszBialek, and James R. Bumby, *Power Systems Dynamics, Stability and Control*, 2nd Ed.New York, New York: John Wiley, 2008.
5. B. Droste-Franke, et al., *Balancing Renewable Electricity – energy storage, demand side management, and network extension from an interdisciplinary perspective*. Heidelberg, Germany: Springer, 2012.
6. I. Hussain, Electric and Hybrid Vehicles : Design Fundamentals, 3rd Ed., CRC Press, 2021.

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Integrated Circuit (I.C.) Technology

DEL	Integrated Circuit (I.C.)Technology	**3L:0T:0P**	**3 Credits**

Pre-requisite:Semiconductor Devices

Objectives:	**Learning Outcomes:**
1. To teach the fundamentals of unit processes for CMOS fabrication, complete VLSI fabrication Technology 2. To discuss the challenges ahead for CMOS, and emerging processes for novel and complementary technologies	1. Learning the scientific principles associated with the technologies used in VLSI fabrication. 2. Understanding of the fabrication methods and unit processes for device and circuit fabrication. Student shall be able to design a fabrication process flow for any discrete device as well as basic circuits. 3. Ability to fabricate discrete devices and to understand the physical properties of the films for electronic device fabrication.

Contents:

1. Introduction: History of integrated circuits, CMOS process flow starting from substrate selection to multilevel metal formation, clean Rooms, cleaning and safety procedures
2. Wafer Manufacturing: Single crystal growth, Czochralski and FZ growth methods, wafer preparation and specifications, SOI Wafer manufacturing
3. Thermal Oxidation: Wet and Dry oxidation of silicon, growth kinetics and models, electronic defects, characterization methods.
4. Optical lithography: Light sources, Wafer exposure systems, Photo resists, Mask making, Mask Engineering, Limits and future trends
5. Solid State diffusion and Ion Implantation: Various Models for diffusion, Manufacturing and Characterization methods, basic concepts for implantation, high/low energy implants, RTA Process & dopant activation Future trends
6. Thin Film Deposition and Etching: Physical and chemical vapor deposition techniques, wet and dry etching, Reactive and plasma etching
7. Back-end Technology: Backend Technology and VLSI/ULSI process integration, Multi-level Interconnects, Silicide formation, planarization, packaging.
8. Modern CMOS Technologies: Design and simulation of process technologies for novel and emerging devices, challenges and future trends

Reference Books:

1. James D Plummer, Michael D Deal, Peter B. Griffin, Silicon VLSI Technology-Fundamentals, Practice And Modelling, Pearson (2009)
2. S.M.Sze, VLSI Technology, Tata McGraw-Hill, 2003
3. Stephen Campbell, Fabrication Engineering at the Micro- and Nanoscale 4/e, Oxford University Press, 2012

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Power System Analysis and Stability

DEL	Power System Analysis and Stability	**3L:0T:0P**	**3 Credits**

Objectives:	**Learning Outcomes:**
To develop understanding of mathematical models to describe power system dynamics	1. Student will learn the concept of stability analysis and understand the difference between steady-state and transient stability analysis. 2. Student will learn to apply different control algorithms to improve power system stability. 3. Develop the expertise to Analyze the impact of renewable energy integration by simulating power system dynamics.

Contents:

Nonlinear systems: Power Systems as non-linear, basic equations of the power system as Ordinary Differential Equations (ODE), Differential Algebraic Equations (DAE), Equilibrium points: Definition, Linearization. Eigen analysis, Stability regions.

Angle Stability and Voltage Stability and the Relationship between two, types of blackouts, voltage collapse, transmission congestion, Availability based tariff, Voltage Compensation, and reactive power contribution to stability, Flexible AC transmission,

Power system stabilizers, lead-lag design, Angle stability, and equal area criterion.

Numerical problems on equal-area criterion, critical clearing time, Synchronous machine response to small-signal perturbation, Small-signal response of machines with voltage regulator, Gain margin, phase margin of single machine infinite bus system (SMIB) systems

Transient stability study of synchronous machines

Bifurcations in swing models of power systems and application of non-linear dynamics tools.

Numerical analysis tools like Runga-Kutta for solving nonlinear equations.

Reference Books:

1. A. R. Bergen and V. Vittal, Power systems analysis, Second Edition, Prentice-Hall, 2000.
2. J. Arrillaga and C. P. Arnold, Computer analysis of power systems, John Wiley, 1990.
3. P. Kundur, Power System Stability and Control, McGraw-Hill, 1994, ISBN 0-07- 035958-X.
4. P. M. Anderson and A. A. Fouad, Power system control and stability, IEEE Press, 1994.
5. C. A. Cañizares, Editor, “Voltage stability assessment: concepts, practices and tools,” IEEE-PES Power System Stability Subcommittee Special Publication, SP101PSS, May 2003.

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Power System Operation and Control

DEL	Power System Operation and Control	**3L:0T:0P**	**3 Credits**

Objectives:	**Learning Outcomes:**
To develop understanding of the real power control and operation, the importance of frequency control, and methods for controlling reactive power.	1. Student will learn the modern numerical techniques and analytical methods for solving operation-related problems in electric power systems. 2. Student will acquire the knowledge to formulate and solve State estimation problems, and generation scheduling formulation and solution techniques.

Contents

Widespread characteristics of modern power systems, evolution, structure, power system control, operating states of a power system and control strategies, economic load dispatch, function and applications, and price-based unit commitment problem.

Concept of reactive power, control of active power and reactive power - active power and frequency control, reactive power flow analysis, real power balance and its effect on system frequency; Static VAR systems, types of SVC, fundamental frequency performance of SVC, application o

Automatic generation control (AGC), generation control loops, load frequency control, AGC, tie-line bias control, AGC in isolated and interconnected power systems, AGC with economic dispatch.

Elements of an excitation system, types of excitation systems, dc, ac, static and recent developments and future trends, dynamic performance measures, large signal, small signal, control and protective functions, ac and dc regulators, design of robust controllers in power systems.

Division of power system into control areas, load-frequency control of single area and two area system - optimum control criterion, two area and multi-areas power system with and without integral control, SCADA systems, supervisory control, supervisory master stations, remote terminal units, communication links, SCADA systems applications in power networks

Reference Books

1. Elgerd O. I., “Electric Energy Systems Theory – An Introduction,” 2nd Ed., Tata McGraw-Hill Publishing Company Limited. 2008
2. Nagrath I. J. and Kothari D. P., “Power System Engineering,” 2nd Ed., Tata Mc-Graw Hill Publishing Company. 2008
3. Grainger J. J. and Stevenson W. D., “Power System Analysis,” Tata McGraw-Hill Publishing Company Limited. 2008
4. Wood A. J. and Wollenberg B. F., “Power Generation, Operation and Control,” Second Edition, Willey – Inter-Science Publications. 2008
5. Kundur P. and Balu N. J., “Power System Stability and Control,” EPRI Series, McGraw- Hill International Book Company. 1998 6. Saadat H., “Power System Analysis,” 1st International Edition, Tata McGraw-Hill Publishing Company Limited.

Industrial Drives

DEL	Industrial Drives	**3L:0T:0P**	**3 Credits**

Pre-requisite: Electrical Machines-I, Power electronics

Objectives:	**Learning Outcomes:**
The Instructor will: Provide understanding of control of various rotating electrical machines used in the industry using power electronic converters	The students are expected to have the ability to: Understand and develop converters and their control methodologies required for various electrical machines used in industry

Contents:

Introduction to Electric Drives – Need of electric drives, basic parts, present scenario of electric drives

Mechanical Dynamics in an Electric Drive - Speed-torque characteristics of some common motors and loads, multiquadrant operation, equivalent values of drive parameters, stability of an electric drive

General Block Diagram of a Closed Loop Drive System – Speed, torque and position control

Selection of Motor Power Rating – Thermal model of motor for heating and cooling, classes of motor duty, determination of motor rating

Chopper Controlled DC Motor Drive – Different types of choppers and their quadrants of operations, PWM strategies for different choppers, chopper control of series DC motor.

Power Semiconductor Switches Used in an Electric Drive System - Basic structure, V-I characteristics and switching characteristics of thyristors and IGBTs, gate drive and protection circuits of thyristors and IGBTs.

DC Motor Drive Using Phase Controlled Rectifier – DC motor drive using half controlled and fully controlled single phase and three phase rectifiers, continuous and discontinuous conduction modes of operation, 4-quadrant operation using dual converter. Closed Loop Control of DC Motor – Operating limits of a separately excited DC motor drive, dynamic model of DC motor, dynamic model of chopper and phase controlled rectifier, design of single loop speed controller, cascaded controller design for DC motor using inner current control loop and outer speed control loop, field weakening operation.

Voltage Source Inverter and its PWM strategies – Basic principles of voltage source inverter, 1200 and 1800 modes of operation, need for pulse width modulation, sine-triangle PWM, space-phasor based PWM, current controlled PWM.

Induction Motor Drive – Steady state equivalent circuit and phasor diagram with variable frequency supply, v/f control and constant air gap flux control of induction motor drive, field weakening operation of induction motor drive.

Synchronous Motor Drive – Synchronous motor drive with Variable Voltage Variable Frequency supply, synchronous motor drive using a voltage source inverter, synchronous motor drive using load commutated thyristor inverter, control of synchronous machine using cycloconverter.

Reference Books:

1. Dubey, G. K., (2001), Fundamentals of Electrical Drives, 2nd Edition, Alpha Science International Ltd

2. De, N. K., Sen, P. K., (1999), Electrical Drives, Prentice Hall of India Pvt Ltd

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Sensors and Actuators

DEL	Sensors and Actuators	**3L:0T:0P**	**3 Credits**

Pre-requisite: Semiconductor Devices/ Introduction to Electronics

Objective	**Learning Outcomes**
The Instructor will : 1. Make the students know about different types of sensors and materials for sensors 2. Use concepts for converting physical parameter into an electrical quantity 3. Explain sensor parameters, different packaging types and readout circuitry\ 4. how and explain examples of sensors relevant to the industry	The students are expected to have the ability to: 1. Identify the commercial and most used sensors in the industry 2. Understand the underlying sensing phenomena used in sensors 3. Develop a synthesis process and characterize a sensor on their own 4. Test and examine the sensor functioning and comprehend as to what needs to be developed

Course Content

Introduction to Sensors and Actuators Different types of sensors, classification of transducers.

Structure of a transducer and types of transducers (Fluidic actuators, Piezoelectric and piezoresistive actuators etc.)

Materials for sensors: Introduction to nanostructured materials, metal oxides, quantum dots,

Parameters and characteristics of Sensors and Transducers, Sensor parameters like sensitivity, selectivity, response- and recovery time, stability, ageing, repeatability, drift, calibration

MEMS and transducers MEMS structural elements, scaling advantages, transduction pathways, examples of electromechanical transduction

Different packaging for Sensors, Premold packaging, Molded interconnect devices, Hermetic packaging, Wafer level packaging

Sensors readouts: Basic circuitry to read the data from sensors, Basic circuitry to read the data from sensors (noise, instrumentation amplifiers etc.)

Current trends in Sensing Applications Few examples of current sensors used in the industry and commercial sensors will be discussed.

Reference Books

1. Jacob Fraden, Handbook of Morden Sensors, Springer 2010.

2. D. V. S. Murthy, Transducers in Instrumentation, Prentice Hall, 1995.

3. J. W. Gardner, Microsensors, Principles and Applications, Wiley, 1996.

4. Silva C. W. de, (2016), Sensors and Actuators, CRC Press

5. Zhang S., Li L., Kumar A., (2009), Materials Characterization Technique, CRC Press

6. Eggins B. R., (2007), Chemical Sensors and Biosensors, Wiley

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Speech Processing

DEL	Speech Processing	**3L:0T:0P**	**3 Credits**

Prerequisite Digital Signal Processing

Objective	**Learning Outcomes**
The instructor will: 1. Introduce the theory of signal processing applications on speech, to give information about human speech production and perception, voice production mechanism, and human perception systems. 2. Provide an understanding of time frequency analysis of speech, Linear Prediction, speech analysis/synthesis.	The students are expected to have the ability to: 1. Analyse digital signals, e.g., audio signals, in the time or frequency domain 2. Implement widely-used algorithms for speech analysis and speech processing in the frequency or time domain.

Contents

Introduction: Review of DSP Basics, Filters, STFT, Spectrogram, Introduction to speech processing, Digitization and Recording, Human Speech Production, Articulatory and Acoustic Phonetics.

Time Domain Analysis: Time domain methods in speech processing, analysis and synthesis of pole-zero speech models, Linear Prediction, perceptually based linear predictive analysis, DPCM

Cepstral Analysis: Time and Frequency domain features. Cepstral Analysis, Mel Cepstral Analysis, MFCC

Hearing Perception

Applications: Compression, Recognition, Noise Suppression, Music Event Classification, Speech Generation.

Textbook

1. Rabiner, L., Schafer, R., (2011), Theory and Applications of Speech Processing, Pearson.

2. Rabiner, L., Schafer, R., (2007), Introduction to Digital speech Processing, Publishers Inc.

3. Quatieri, T. F., (2011), Discrete-Time Speech Signal Processing, Prentice-Hall.

Self-Learning Material:

1. Mandal S., Electronics & Communication Engineering, IIT Kharagpur https://nptel.ac.in/syllabus/117105145/

Preparatory Course Material

2. Dutta Roy S. C., Digital Signal Processing, NPTEL Course Material, Department of Electrical Engineering, Indian Institute of Technology Delhi, https://nptel.ac.in/courses/117102060/

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Signal Compression

DEL	Signal Compression	**3L:0T:0P**	**3 Credits**

Pre-requisite: Information and Signals

Objective	**Learning Outcomes**
To develop skills to represent information with	Student will learn the concepts and techniques to represent the signal efficiently for storage, transmission and analysis.

Contents:

1. Introduction: signal representations, common audio, video and image signals, redundancies in signal: statistical, perceptual, coding, spatial and temporal.

2. Perceptual redundancies and compression: Human perception and sensitivity of various signals, Webers law, mu-law, Steven's law, quantization and Just Noticable Difference (JND), DCT and wavelets, KLT, JPEG compression.

3. Data redundancies and compression: spatial and temporal correlations, time-frequency analysis, motion vectors, MPEG coding.

4. Coding redundancies and compression: Run length coding, Huffman and Arithmetic coding, Lempel and ziv method, differential pulse code modulation (DPCM).

Reference Books:

1. Khalid, S., (2017), Introduction to Data Compression, Elsevier

2. Solomon, D., (2007), Data Compression, The complete Reference, Springer

Computer Networks

DEL	Computer Networks	**3L:0T:0P**	**3 Credits**

Pre-requisite: Communication Systems

Objectives:	**Learning Outcomes:**
1. To understand the organization of computer networks, factors influencing the performance of computer networks, and the reasons for having a variety of different types of networks	1. The students will learn the essential protocols of computer networks in terms of design, implementation & operations. 2. The students will be able to identify various design parameters such as latency, bandwidth, error rate, throughput, and their influence on node/link utilization and performance

Contents:

1. Introduction: Layer approach, Fundamentals of physical layer, Performance metrics: delay, loss, throughput, bandwidth delay product, latency
2. Link Layer: Fundamentals of error detection, CRC, retransmission strategies, multiple access protocols, random access techniques, FDMA, TDMA, CDMA, Reservation, polling, token ring and buses, High speed LANs.
3. Network Layer: Internetworking, Tunneling, Encapsulation, Fragmentation, Internet protocol and its operation, Routing algorithms distance vector and link state algorithm and Routing protocols.
4. Transport Layer: Transmission Control Protocol, Flow control, Error control, Congestion control, Header, Services, Connection management, Timers, Congestion control; User Datagram Protocol, Introduce low latency protocols (WebRTC, LHLS), Applications (IoT and FOG, Real-time applications, ad-hoc wireless protocols).
5. Applications: Network programming, Socket abstraction, Peer-to-peer architecture (P2P architecture), Client server architecture, DNS, HTTP, FTP, SMTP, TelNet, etc.
6. Advanced Internetworking: Multicast routing, Queuing disciplines and buffer management techniques.
7. Network security: Public key and private key cryptography, Digital signature, Firewalls.

Reference Books:

1. Data Communication and Networking, B. A. Forouzan, Mc Graw Hill, 2017, Fifth Edition
2. Computer Networking – A top down approach featuring the Internet, J.F. Kurose and K. W. Ross, Pearson, 2016, 7th Edition.
3. Data and Computer Communications, W. Stallings, Pearson, 2013, 10th Edition.

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Microwave Engineering

DEL	Microwave Engineering	**3L:0T:0P**	**3 Credits**

Pre-requisite: Electromagnetic Theory

Objectives:	**Learning Outcomes:**
To develop the fundamental understanding of electromagnetic waves and propagation. Basic understanding of high frequency circuit analysis and design.	1. Understanding of Electromagnetic waves and its propagation through various medium. 2. Understanding of the circuit behavior at RF-microwave frequencies. 3. Fundamental ideas of microwave circuit design.

Contents:

1. Maxwell's equations and development of wave equations. Solution of wave equation, idea of wave and intrinsic impedances, propagation of waves in free space, lossy dielectric and conducting medium, skin depth and surface resistance.
2. Introduction of transmission line, Telegrapher's equation, characteristics impedance, lossy and lossless lines, input impedance of terminated transmission lines, standing of ratio, reflection and transmission, power flow, dispersion in transmission line, quarter wave transformer, Smith chart, single and double stub matching.
3. Scattering-matrix, representation, properties, shift in reference planes, generalized S-matrix; Signal flow graph, transmission line resonators, discussion of some basic passive components like 1:2 power divider, directional coupler, magic tee.
4. RF Schottky diode, three term approximation of diode's I-V characteristics, GUNN diode and its modes of operation, PIN diode, application of Schottky diode as a detector, frequency translator, PIN diode switches.
5. MESFET, GaN HEMT, small signal equivalent model of the transistors at RF frequencies.
6. Discussion on basic building blocks of RF transceiver and need of RF design, idea of small antenna, basic dipole and monopole antennas, radiation pattern, gain and directivity of antenna.

Reference Books:

1. D. M. Pozar, (2011), "Microwave Engineering," 4th ed. New York, NY, USA, Wiley.

2. David K. Cheng, (1989), Fields and Waves Electromagnetics, 2nd edition, Pearson Education.

3. Balanis C. A., (2016), Antenna Theory, Analysis and Design, 4th edition, Wiley Press.

4. B. Razavi, RF Microelectronics, 2nd Edition, Pearson Education, 2014.

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Bouquet of HSS/ Management Courses

Sl. No.	Course	L	T	P	C
1	Economics	3	0	0	3
2	Psychology	3	0	0	3
3	Sociology	3	0	0	3
4	Industrial Management	3	0	0	3
5	Organization Behaviour	3	0	0	3

APPENDIX

Appendix –I

Indian Knowledge Systems

IKS-I: Indian Knowledge Systems and Traditions

Course Objectives

- To sensitize the students about context in which they are embeded i.e. Indian culture and civilisation including its Knowledge System and Tradition.
- To help student to understand the knowledge, art and creative practices, skills and values in ancient Indian system.
- To help to study the enriched scientific Indian heritage.
- To introduce the contribution from Ancient Indian system & tradition to modern science & Technology

Detailed contents:

Module 1: Introduction to IKS

(Any eight of total sessions assigned for Literary activity)

Introductory lecture on the **any eight** topics below:

1. Indian Knowledge System
2. Indian Culture & Civilization
3. Ancient Indian Chemistry
4. Ancient Indian Metallurgy
5. Ancient Indian Mathematics
6. Ancient Indian Astronomy
7. Indian Astronomical Instruments
8. Indian Knowledge System (Upveda: Ayurveda)
9. Indian Knowledge System (Upveda: Gandharveda)
10. Indian Knowledge System (Vedangas: Shiksha, Kalpa, Vyakrana)
11. Indian Knowledge System (Vedangas: Jyotisha, Nirukta, Chandas)
12. Indian Architecture I: Sthapatya-Veda
13. Indian Architecture II: Temples
14. Indian Architecture III: Town & Planning
15. Indian Philosophical System

Module 2: Introduction to Creative Practices

(Twenty Lectures with at least Five different topics of total session under Creative activity)

Introductory lecture on the topics below:

1. Dhatuvada: art of metallurgy
2. Akara jnana: art of mineralogy
3. Vastuvidya: art of engineering
4. Yantramatrika: art of mechanics
5. Takshana: art of carpentry

6. Chalitakayoga: art of practicing as a builder of shrines
7. Raupyaratnapariksha: art of testing silver and jewels
8. Maniraga jnana: art of tinging jewels
9. Sucivayakarma: art of needleworks and weaving
10. Vadya vidya: art of playing on musical instruments
11. Geet vidya : art of singing
12. Nritya vidya: art of dancing
13. Natya vidya: art of theatricals
14. Alekhya vidya: art of painting
15. Viseshakacchedya vidya: art of painting the face and body with color
16. Udakavadya: art of playing on music in water
17. Manasi kavyakriya: art of composing verse
18. Bhushanayojana: art of applying or setting ornaments
19. Citrasakapupabhakshyavikarakriya: art of preparing varieties of delicious food
20. Dasanavasanangaraga: art of applying preparations for cleansing the teeth, cloths and painting the body
21. Utsadana: art of healing or cleaning a person with perfumes
22. Vastragopana: art of concealment of cloths
23. Balakakridanaka: art of using children's toys
24. Tandulakusumabalivikara: art of preparing offerings from rice and flowers
25. Pushpastarana: art of making a covering of flowers for a bed

References:

1. Textbook on IKS by Prof. B Mahadevan, IIM Bengaluru
2. Kapur K and Singh A.K (Eds) 2005). Indian Knowledge Systems, Vol. 1. Indian Institute of Advanced Study, Shimla. Tatvabodh of sankaracharya, Central chinmay mission trust, Bombay, 1995.
3. The Cultural Heritage of India. Vol.I. Kolkata:Ramakrishna Mission Publication, 1972.
4. Nair, Shantha N. Echoes of Ancient Indian Wisdom. New Delhi: Hindology Books, 2008.
5. Dr. R. C. Majumdar, H. C. Raychaudhuri and Kalikinkar Datta: An Advanced History of India (Second Edition) published by Macmillan & Co., Limited, London, 1953.
6. Rao, N. 1970. The Four Values in Indian Philosophy and Culture. Mysore: University of Mysore.
7. Avari, B. 2016. India: The Ancient Past: A History of the Indian Subcontinent from c. *7000* BCE to CE 1200. London: Routledge.

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IKS-II: Indian Culture and Civilization

Course Objectives

- To introduce fundamentals of Ancient Indian Educations to understand the pattern and purpose of studying vedas, vedangas, upangas, upveda, purana & Itihasa
- To help students to trace, identify and develop the ancient knowledge systems.
- To help to understand the apparently rational, verifiable and universal solution from ancient Indian knowledge system for the holistic development of physical, mental and spiritual wellbeing
- To build in the learners a deep rooted pride in Indian knowledge, committed to universal human right, well-being and sustainable development.

Detailed contents:

Module 1: Introduction to IKS

Caturdaśa Vidyāsthānam, 64 Kalas**,** Shilpa Śāstra, Four Vedas, Vedāṅga, Indian Philosophical Systems, Vedic Schools of Philosophy (Sāṃkhya and Yoga, Nyaya and Vaiśeṣika, Pūrva-Mīmāṃsā and Vedānta), Non-Vedic schools of Philosophical Systems (Cārvāka, Buddhist, Jain), Puranas (Maha-puranas, Upa-Puranas and Sthala-Puranas), Itihasa (Ramayana, Mahabharata), Niti Sastras, Subhasitas

Module 2: Foundation concept for Science & Technology

Linguistics & Phonetics in Sanskrit (panini's), Computational concepts in Astadhyayi Importance of Verbs, Role of Sanskrit in Natural Language Processing, Number System and Units of Measurement, concept of zero and its importance, Large numbers & their representation, Place Value of Numerals, Decimal System, Measurements for time, distance and weight, Unique approaches to represent numbers (Bhūta Saṃkhya System, Kaṭapayādi System), Pingala and the Binary system, Knowledge Pyramid, Prameya – A Vaiśeṣikan approach to physical reality, constituents of the physical reality, Pramāṇa, Saṃśaya

Module 3: Indian Mathematics & Astronomy in IKS

Indian Mathematics, Great Mathematicians and their contributions, Arithmetic Operations, Geometry (Sulba Sutras, Aryabhatiya-bhasya), value of π, Trigonometry, Algebra, Chandah Sastra of Pingala,

Indian Astronomy, celestial coordinate system, Elements of the Indian Calendar Aryabhatiya and the Siddhantic Tradition Pancanga – The Indian Calendar System Astronomical Instruments (Yantras) Jantar Mantar or Raja Jai Singh Sawal.

Module 4: Indian Science & Technology in IKS [Duration: 8 Lectures]

Indian S & T Heritage ,sixty-four art forms and occupational skills (64 Kalas) Metals and Metalworking technology (Copper, Gold, Zinc, Mercury, Lead and Silver), Iron & Steel, Dyes and Painting Technology), Town & Planning Architecture in India, Temple Architecture, Vastu Sastra,

Module 5: Humanities & Social Sciences in IKS [Duration: 8 Lectures]

Health, Wellness & Psychology, Ayurveda Sleep and Food, Role of water in wellbeing Yoga way of life Indian approach to Psychology, the Triguṇa System Body-Mind-Intellect- Consciousness Complex. Governance, Public Administration & Management reference to ramayana, Artha Sastra, Kauṭilyan State

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IKS-III: Indian Vision for Human Society (Vishva Kalyan thru Vasudhaiva Kutumbkam)

Course Objectives

- To help the learner to understand the concept of "vasudhaiva kutumbkam" and its realization process as an base for the development of vision for a humane society.
- To help to identify the universality in humans and its coexistence in existence
- To introduce the sense of responsibility, duties and participation of individual for establishment of fearless society.
- To help to understand the apparently rational, verifiable and universal solution from ancient Indian knowledge system for the holistic development of physical, mental and spiritual wellbeing of one and all, at the level of individual, society, nation and ultimately the whole world.

Detailed contents:

Module 1: The world view & Vision of Human Society

The concept of non-duality of Prakriti (Jad) and Purush (Chetana), human as coexistence of Jad & Chetan, Pancha-mahabhutas, the root of sorrow and suffering, freedom from sorrow, salvation, eternal peace truth (vyaharika satya), ultimate truth. The acceptance of various systems of philosophy for realization of truth and complementariness in society in ancient Indian system.

Module 2: Aspiration and Purpouse of Individual and Human Society

Aims of Human life; at individual level and societal level. At societal level; Four purusarthas Dharma, Artha, Kama, Moksha. Individual level; Abhyudaya (progress),

Nihsreyasa (perfection) Pravrtti , Nivrtti. Dharma; Dharma sutras (Gautama, apastamba, baudhayana, vasistha). Dharma-Shastra; (manusmriti, naradamrti, visnusmrti, yajnavalkya smriti) sociology, different stages of life like studenthood, householdership, retirement and renunciation, rites and duties, judicial matters, and personal laws (Aachara, Vyavahara, Prayaschitta). Artha; Kautliya Arthashastra, Kamandakiya Nitisara, Brihaspati Sutra, Sukra Niti, Moksha: Human liberation (Ignorance to Knowledge)

Module 3: Program for Ensuring Human Purpose: at Individual and Societal level –I

Fundamental concept of Nitishastra: Satyanishtha Aur Abhiruchi (Ethics, Integrity & aptitude). The true nature of self; Shiksha Valli, Bhrigu Valli (concept of Atman-Brahman (self, soul). The true constitution of Human: Ananda Valli (Annamaya Kosha, Pranamaya Kosha, Manomaya Kosha, Vijnanamaya Kosha, Anandamaya Kosha)**.** The four states of consciousness (Waking state, Dreaming state, Deep Sleep State, Turiya the fourth state), Consciousness (seven limbs and nineteen mouths), Prajna, Awarness**.** The Life Force *Prana (*Praana-Apaana-Vyaana-Udaana- Samaana)

Module 4: Program for Ensurimg Human Purpose: at Individual and Societal level - II

Differentiating *Vidya* and *Avidya*, human bondages, Higher and Lower Knowledge (Para Vidhya & Apara Vidhya). Concept of Sattva, Rajas, Tamas and need of balancing the same, Patanjali yog sutra; Yama, Niyama, Asanas, pranayams, pratyahara, dharna, dhyana, Samadhi, Sixteen category of padartha, pramans (pratyaksh, anuman, upaman, shabda). Saadhana chatushtayam (viveka, vairagya, mumukshatavam, shadsampathi (sama, dama, uparama, titiksha, shradha, samadhana), Understanding Nitya karma, Naimittika Karma, Kamya karma, prayaschitta karma, Nishidha Karma.

Meditation and Progressive meditation (Narada's education), Ativadin to self-knowledge, Jyan yog, Karma yog, sanyas yog in aspect to harmonious practice in society

Module 5: Practices for Ensuring Human Purpose – III

Practice in philosophy, architecture, grammar, mathematics, astronomy, metrics, sociology, economy and polity, ethics, geography, logic, military science, weaponry, agriculture, mining, trade and commerce, metallurgy, shipbuilding, medicine, poetics, biology and veterinary science.

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IKS-IV: Indian Science, Engineering and Technology (Past, Present and Future)

Course Objectives

- To familiarize learners with major sequential development in Indian science, engineering and technology.
- To review & strengthen the ancient discovery and research in physics, chemistry, maths, metallurgy, astronomy, architecture, textile, transport, agriculture and Ayurveda etc.
- To help students to trace, identify and develop the ancient knowledge systems to make meaningful contribution to development of science today
- To help to understand the apparently rational, verifiable and universal solution from ancient Indian knowledge system for the scientific, technological and holistic development of physical, mental and spiritual wellbeing.

Detailed contents:

Module 1: Indian Traditional Knowledge; Science and Practices

Introduction to the Science and way of doing science and research in India, Ancient Science in Intra & Inter Culture Dialogue & coevolution.

Traditional agricultural practices, Traditional water-harvesting practices, Traditional Livestock and veterinary Sciences Traditional Houses & villages, Traditional Forecasting, Traditional Ayurveda & plant based medicine, Traditional writing Technology

Module 2: Ancient Indian Science (Physics, Chemistry, Maths)

Physics in India: Vaisheshika darshan Atomic theory & law of motion, theory of panchmahabhoota, Brihath Shathaka (divisions of the time, unit of distance), bhaskarachaya (theory of gravity, surya siddhanta & sidhanta shriomani), Lilavati (gurutvakashan Shakti).

Chemistry in India Vatsyayana, Nagarjuna,Khanda, Al-Biruni, Vagbhaṭa – building of the ras-shala (laboratory), working arrangements of ras-shala, material and equipment, Yaśodhara Bhaṭṭa-process of distillation, apparatus, saranasamskara, saranataila

Mathematics in India: Baudhayana's Sulbasutras, Aryabhaṭa, Bhaskaracharya-I, Severus Sebokht, Syria, Brahmagupta, Bhaskaracharya-II, Jyeṣṭhadeva

Module 3: Ancient Indian Science (metallurgy, Astronomy, Architecture)

Metallurgy in India: Survarṇa(gold) and its different types, prosperities, Rajata(silver), Tamra(copper), Loha(iron), Vanga(tin), Naga / sisa(lead), Pittala(brass)

Astronomy in India Vedang Jyotish, aryabhatta siddhanta, Mahabhaskriya, Laghubhaskariya, vatesvarasiddhanta, Sisyadhivrddhida, Grahashyay, Goladhyaya, Karabakutuhala **(**Aryabhaṭa, Varahamihira, Brahmagupta, Vaṭesvara, Bhaskara, Paramesvara, NilakaṇṭhaSomayaji, Jyeṣṭhadeva, ŚankaraVarman)

Architecture in India: Nagara (northern style), Vesara (mixed style), and Dravida (southern style), Indian vernacular architecture, Temple sytle, cave architecture, rock cut architecture, kalinga architecture, chandels architecture, rajput architecture, jain architecture, sikh architecture, Maratha architecture Indo-Islamic architectural, Indo-Saracenic revival architecture, Greco Buddhist style.

Module 4: Ancient Indian Science (Textile, Agriculture, Transport)

Textile Technology in India: Cotton (natural cellulose fiber), silk, wool (natural protein fibers), bast and leaf fibers, mridhudhautadhupitambaram (meaning a practice of fumigating the fabric with incence smoke before use as a part of the finishing process), sitadhautavasanayugala (bleached white–a finishing process); suchhastah, sutradharah (needle and thread – tools for stiching). dyeing, washing spinning and weaving technology,Agriculture in India: krishisuktas, Krishiparashara, Brihatsamhita, Types of crops, Manures, Types of land- devamatruka, nadimatruka, use of animals in warfare, animal husbandry, Animals for medicines. Ancient transport in India

Module 5: Ancient Indian Science (Ayurveda & Yoga)

Ayurveda for Life, Health and Well-being**:** Introduction to Ayurveda: understanding Human body and Pancha maha bhuta, the communication between body & mind, health

regimen for wellbeing, introduction to yoga (raja yoga, astang yoga, gyan yoga), understanding of Indian psychological concept, consciousness, tridosha & triguna.

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IKS-V: Indian Town Planning and Architecture

Course Objectives

- To develop the knowledge and analysis on the understanding of eco-friendly, robust and scientific planning and architecture system of ancient India.
- To understand the importance of functional, aesthetic, psychological, culture and socio religious concept of ancient India architecture.
- To help the learners to trace, identify and develop the approach, process and material used in town and planning, construction and architecture
- To review and analyse the importance and significance of visual and performing arts and design in temples, houses, forts, caves and community places.
- To understand the various eco-friendly technology accepted in ancient civilization

Detailed contents:

Module 1: The Introduction to ancient Architecture

Introduction to relationship between Man, Nature, Culture and city forms. Study of determinants (Natural and man-made) influencing location, growth & pattern of human settlements including types of settlements growth (Organic and Planned) and settlement forms.

Architecture as satisfying human needs: functional, aesthetic and psychological outline of components and aspects of architectural form-site, structure, skin, materials, services, use, circulation, expression, character, experience.

Understanding of the causative forces - the cultures, history, socio religious practices and institution, political and economic conditions, issues of land, climate and technology, Historical and Primitive Architecture.

Module 2: Ancient Architecture as Expression of Art & Design

Relationship between Art and Design with man, space and environment. Expression in Art and Architecture – concept of space, sense of enclosure-openness, robustness, dynamism, spatial geometry, Eco-friendliness.

Architecture through use of elements of visual arts such as point, line, plane, form, space, colour, texture, light, solids and voids, shadow and shade etc. Understanding of effect of scale, proportions, order, material effects such as textures, patterns, light, sound, temperature etc in architectural spaces.

Allied visual and performing arts and its relationship to build environments using colour theory, symbolism, glass painting, scriptural writing, clay moulding, stone carving.

Important Indian architecture as per elements space & form **Form:** specific geometry form (sphere, cube, pyramid, cylinder and cone and its sections as well as their derivatives) **Space:** build form space, open space, Internal and External space, Continuous spaces Centralized, Linear, Radial Clustered, Grid space Different type of Materials used for construction in Ancient Indian architecture.

Clay products: Classification of bricks, Fire Brick, Fly Ash Bricks, Tiles, Terra-cotta, Earthenware, Porcelain, Stoneware. **Stones:** Uses of Stones, Qualities of Good Building Stones, Dressing, Common Building Stones of India. **Glass:** Different glass Forms and their Suitability, **Timber**: Different Forms and their Suitability **Metals:** Ferrous & Nonferrous Metals and Alloys, and, their Suitability, limitations, precautions **Paints and Varnishes:** Different types and their Suitability, limitations, precautions

Module 3: Ancient Architecture Principle & Planning

Design: Principles of designing – Composition of Plan. Inception and development of the early Hindu temple form with reference to Vedic and Buddhist planning principles and design elements; Development of regional styles and manifestations thereof; Evolution of temple complexes and temple towns;

Planning: Residence- site selection, site orientation- aspect, prospect, grouping, circulation, privacy, furniture requirements, services and other factors. Vastu shastra and its importance in building interrelationship with human, nature and cosmos

Town Planning: Town plans of Harappa, Mohenjodaro, Pataliputra, Delhi. Vastu shastra and its application in city layout.

Module 4: Ancient Architecture-I

The settlement planning pattern, elements, associated forms, typical Vedic village, towns (Dandaka, Nandyavartha etc.), typology of Shelters and civic buildings of ancient architecture in reference to following civilization: Indus

Valley, Aryan/vedic Civilisation, Buddhist Architecture, Indo Aryan & Dravidian Architecture.

Role of Shilpasasthras and Arthashasthra in settlement planning.

Important architecture: Great baths, Development of fortification, walled towns, structures developed eg: Stupas, Viharas, Chaityas, Stambhas, Toranas, sacred railing etc.

Study of worshipping places with especial reference to Indo Aryan / Nagara style & Dravidian style (Chola, Chalukya, Pallava, Satavahana, Hoysala, Vijayanagara etc.), design of shikharas & gopuram, rock-cut and structural examples of temples.

Module 5: Ancient Architecture-II

Evolution of Hindu Temples in different period: Gupta, Aihole, Badami, Pattadakkal, Mahabalipuram, Indo Aryan Style in Orrisa, Khajuraho, Gujarah, Rajasthan. Dravidian Style in Chola, Chalukyan, Pandya, Pallava, Hoysala Style, Revival of Hindu architecture of South India at Vijaynagara and Madurai

Tradition Indian villages & House: Regional house construction, interior & importance e.g. Rajasthani house, bhungas of kutch, nalukettu of kerala, Ikra of assam, manduva logili or illu of Andra Pradesh, wadas of Maharashtra, Mud houses of Madhya Pradesh, kathkuni of himachal Pradesh, khanjaghara of orisa, Taq and dhajji diwari of Kashmir etc.

Scientific achievements though ancient architect: Jantar Mantar, Musical Pillars of Vitthal temple, Sundial of konark temple, construction of eight shiva temple in straight line from Kedarnath to rameshwaram at longitude 79°E 41'54, Veerbhadra temple with 70 hanging pillars, Ellora caves excavating the mountain, Jaipur plan pink city etc.

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13. Anant Shashikala, The Penguine Guide to Vaastu, the classical Indian science of architecture & design, penguin India, 2000

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IKS-VI: Indian Mathematics and Astronomy

Course Objectives

- To provide information about great mathematicians and astronomers who given significant contribution in Indian mathematics and astronomy.
- To help students to trace, identify, practice and develop the significant Indian mathematic and astronomical knowledge.
- To help to understand the astronomic significance with the human holistic development of physical, mental and spiritual wellbeing
- Enumerate the main characteristics of education system in Vedic and post Vedic period to enrich the intellectual imagination and diminish the dogmatic assurance which closes the mind against speculation

Detailed contents:

Module 1: The Introduction to Ancient Mathematics & Astronomy

Introduction to Brief introduction of inception of Mathematics & Astronomy from vedic periods. Details of different authors who has given mathematical & astronomical sutra (e.g. arytabhatta, bhaskara, brahmagupta, varamahira, budhyana, yajanvlkya, panini, pingala,

bharat muni, sripati, mahaviracharya, madhava, Nilakantha somyaji, jyeshthadeva, bhaskara-II, shridhara)

Periodical enlisting of Mathematical & Astrological achievement in India. Evolution of Indian Numerals (Brahmi (1st century), Gupta (4th century) & Devanagri Script (11th century)

Module 2: Ancient Mathematics –I

Veda & Sulvasutras (Pythagoras theorem, Square root & Squaring Circle) (baudhayana sulbhasutra, apastamba sulbhasutra, katyayana sulbhasutra, manava sulbhasutra, maitrayana sulbhasutra, varaha sulbhasutra, vadhula sulbhasutra , Pingala's chandasutras, sunya, yaat-tavat, Aryabhata (Aryabhatiya, Asanna, ardha-jya, kuttaka,), bhaskara (trigonometory,shridhara,

mahavira), Bhaskara Acharya (Sidhantashiromani), Varamahira panchasiddhantika.

Module 3: Ancient Mathematics –II

Brahamgupta (vargaprakrati, bhramasphuta siddhanta, bhavana), ayatavrtta, ganitasarasamgraha, lilavathi, ganesadaivajna, randavantika, suryasidhhanta, grahalaghava, sadratnamala, mandavrtta, sighrartta, Bijaganita, Bakshali manuscript

Golavada, Madhyamanayanaprakara, Mahajyanayanaprakara (Method of Computing Great Sines), Lagnaprakarana, Venvaroha, Sphutacandrapti, Aganita-grahacara , Chandravakyani (Table of Moon-mnemonics)

Module 4: Ancient Astronomy –I

Parahita system of astronomy and drk system of astronomy, Manda samskara, sighra samskara.

Vedanga Jyotisha (astronomical calculations, calendrical studies, and establishes rules for empirical observation), Aryabhatiya (earth rotation, shining of moon), Brahmasphutasiddhanta (motion of planets), varahmihira (pancasiddhantika), Mahabhaskariya, lahubhaskariya & arybhatiya bhashya (Planetary longitudes, heliacal rising and setting of the planets, conjunctions among the planets and stars, solar and lunar eclipses, and the phases of the Moon), Sisyadhiveddhida (grahadhyaya, goladhyaya), siddhantasiromani, karanakutuhala (planetary positions, conjunctions, eclipses, cosmography), siddhantasekhara, yantra-kirnavali, Sphuṭanirṇaya, Uparagakriyakrama.

Module 5: Ancient Astronomy –II

Positional astronomy (sun, planets, moon, coordinate systems, precision of the equinox and its effects, eclipses, comets and meteors), Mahayuga & Kalpa system Yuga system, ayanas, months, tithis and seasons, time units, sun and moon's motion, planet position, ayanachalana, zero-precision year, katapayaadi system, Indian nakshatra system, astronomy

Instruments for naked eye astronomy (vedic observatories). The principal and application of Samrat Yantra, Jai Prakash Yantra, Disha Yantra, Rama Yantra, Chakra Yantra, Rashiwalya Yantra, Dingash Yantra, Utaansh Yantra

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IKS-VII: Indian Aesthetics (including Music and Music Instruments)

Course Objectives

- To provide information about the foundations of Indian aesthetics as integral part of Indian culture
- To help to understand the importance of Indian aesthetics in individual realization of the truth arises by realizing the harmony within.
- To help learner to trace, identify and develop the Indian aesthetics to correlate human creative practices
- To build the learners a deep rooted pride in Indian aesthetic knowledge, committed to universal human right, well-being and sustainable development.

Detailed contents:

Module 1: The Introduction to Indian Aesthetics

The nature of aesthetics, principle, its relation to philosophy and literature:

Indian traditions. Sadanga its origin and Applications of Six limbs in Indian Aesthetics Introduction to Alamkara, Rasa, Dhvani, Vakrokti, Auchitya

Module 2: Ancient Music and Music Instruments-I

Rasa Siddhanta, the concept of Rasa, constituent of rasa (Bhav, abhinay, Sthayibhava, Vibhava, Vyabhicharibhava), number of rasa, Rasasvadana Bharata's Natya Shastra and its Critics, Abhinavagupta's Rasa Siddhanta., Kāvyaprayojana, Sādhāranikarana, Sahrdaya, Rasavighna.

DhvaniSiddhanta, the Concept of Dhvani, Sphota, Pratibhā, classification of dhvani (Laukika Vyangya, Alaukika Vyangya, Avivaksita Vacya, Vivaksitanyapara Vacya) Anandavardana's Dhanyaloka, with reference to Abhidha, lakshana, Vyanjana and Tatpary, extension of dhvani siddhanta to music, dance and drama.

Alamkara Siddhanta, proponent, classification of alamkara, sabdalamkara (Anuprāsa, Yamaka, Ślesha, Dhvanyātmakatā), Arthālamkāra (Upamā, Drstanta, Virodha)

Module 3: Ancient Music and Music Instruments-II

VakroktiSiddhanta, Kuntaka's Vakroktijivita, Classification of Vakrokti (Varna-vinyasa vakrata (Phonetic Obliquity), Pada-purvardha vakrata (Lexical Obliquity) & Pada-parardha vakrata (Grammatical Obliquity), Vakya-vakrata (Sentential obliquity), Prakarana-vakrata (Episodic obliquity), Prabandha-vakrata (Compositional obliquity))
Different Classes of Musical Instrument as per Natyashastra of Bharat, Gana Vadya, Avanaddha Vadya, sushira vadya, tata/tantu vadya.
Brief introduction to following indian instruments
Veena, Ghatam, Gootuvadhyam, Flute, Thavil, Nadaswaram, Mridangam, Plain-drum, Harmonium, Sitar, Sarod, Shehnai, Tabla, Maddalam, violin, morsing, Tambura.

Module 4: Ancient Dance & Drama

Natyaveda: inception from Veda (pathya words(rigveda), abhinaya gestures (Yajureda), geet music (samaveda), rasa emotions (atharvaveda), Natya Shastra, Nata-nritya, geet- nritya, roop-nritya, bhav-nritya

Indian traditional and fork dances (bharatnatyam, kuchipudi, kathakali, yakshagan, Bhangra, Bihu, Ghumura Dance, Sambalpuri, Chhau and Garba

Module 5: Ancient Art

Architecture, sculptures & popular art forms of Pallava& Cholas period, Chalukya & Rastrakuta period, Chandela/Hosalya period, Rajput period. Rock

cut architecture, cave architecture, stupa, temples, sculpture

Hindu Shilpa texts as per Vishnudharmotara-puran, Samaranana, Sutracharana, Sukranitisara, Silparatham

Reference:

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IKS-VIII: Indian Health, Wellness and Psychology (including Ayurved)

Course Objectives

- Understanding the fundamental principles of Indian health systems such as Ayurveda and yoga which are useful in maintaining the health of a healthy person
- Practical implementation of health principles to correct the intake of our food, air, water and sunlight to achieve perfect health.
- Understanding traditional way of cleansing the body regularly, strengthening body with Yogic exercises, maintaining the internal balance to prevent diseases.
- Understanding our unique Mind Body Constitution and choosing the right lifestyle suitable to maintain the internal balance.
- Understanding the influence of external environment on internal health and ways to synchronise our body and mind with nature to ensure smooth functioning of all organ systems of our body.
- Understanding mind and its dynamics through knowledge of Ayurveda and Yoga and using the knowledge to maintain harmony between body and mind to achieve perfect mental health.

Detailed contents:

Module 1: Understanding human body [Duration: 8 Lectures]
Introduction to Ayurveda, the Knowledge of Life, Health and treatment aspects in Ayurveda, Influence of Pancha maha bhuta on Internal environment of Human being, Understanding composition of Human body through the concept of Dosha Dhatu Mala, Understanding Prakruthi , the Mind – Body Constitution.

Module 2: Understanding the communication between body & Mind

Establishing communication between body and mind by understanding the language of body. Understanding the concept of Agni, Koshta, Sara and Ojas and their relevance in enhanching our immunity to protect from various infections. Looking at the world through the lenses of Dravya, Guna and Karma Applying the principle of Samanya and Visesha in every aspect of life to achieve perfect health.

Module 3: Introduction to Health Regimen

Understanding Swastha vritta, the healthy regimen to maintain state of wellbeing Dinacharya, the Daily regimen including Daily detoxification, exercise, Intake of Food, Water, Air and Sunlight, work and ergonomics, Rest and sleep hygiene. Ritu charya, the seasonal regimen, Sadvritta and the concept of social wellbeing, understanding trividha upastambhas, three pillars to health, Concept of Shadrasa in choosing appropriate nourishment to the body and mind.

Module 4: Introduction to Yoga

Definition, Meaning and objectives of Yoga, Relevance of yoga in modern age. Brief Introduction of Hatha yoga, Raja yoga, Karma yoga, Gyana Yoga, Bhakti yoga Understanding eight steps of Ashtanga yoga, Understanding Shatkriyas , the six cleansing procedures of Yoga

Module 5: Introduction to Indian Psychology

Concept of Manas in Ayurveda and understanding Mind Body harmony, Triguna based Psychology in Ayurveda and Yoga, Influence of Tri dosha on Mind, Mind body intellect and consciousness complex, Understanding Consciousness and solution to issues within Human Mind.

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Appendix – II

Internship/ Capstone Project

Course Objective(s):

This internship capstone course aims to provide students with an integrative learning experience that combines professional work in a real-world organisation with rigorous academic research. Students will develop and apply theoretical knowledge to practical challenges through an action research project, enhancing their problem-solving, critical thinking, and communication skills. This course aims to bridge the gap between academic study and professional practice, preparing students for successful careers in their chosen fields.

Internship/ Capstone Project Student Engagement Process:

An internship/capstone project is a structured, hands-on learning experience integrating academic knowledge with pre-professional work activities. It mutually benefits both the student-intern and the host organisation. Interns apply foundational skills from their studies to real-world tasks, enhancing their practical experience. Placement sites outline clear expectations, duties, and performance goals for the interns. They also offer regular supervision and feedback to guide the interns' development. This experiential learning helps students build valuable industry-specific skills, gain insights into their chosen field, and improve their employability upon graduation.

Step 1.

Orientation Session: The orientation session for the internship/capstone project is designed to provide students with a comprehensive overview of what to expect and how to succeed in their upcoming professional experience. The session aims to bridge the gap between academic learning and practical application in a real-world setting.

Step 2.
Identify an internship: Students research opportunities that align with their career goals and academic background. They explore various platforms, such as online job boards, networking events, and professional associations, to find positions that offer relevant hands-on experience and skills in their chosen field.

Step 3.

Internship agreement Form: The Student, Mentor, and internship Coordinator in the Industry will complete the internship agreement form.

Step 4.

Start of Internship: The internship lasts eight weeks. Interns are expected to commit to 20 hours per week, allowing for a balanced integration of work and learning. The internship mentor will arrange specific schedules. This structure ensures that interns gain substantial experience while accommodating any academic commitments. Regular check-ins and progress reviews will be conducted to support intern development and address any challenges, providing a productive and enriching internship experience.

Step 5.

Submission of Report:
Front Page: Student Name, Course, Internship Company, Duration, Mentor
Internship Agreement Form
Internship Certificate
Introduction & background of the Company
Roles & responsibilities as an Intern
Weekly work allotment & completion report
Challenges & Solutions
Learning from the internship
Conclusion

Step 6.

Internship Evaluation: The Viva Voce for internship evaluation is an oral exam where interns present their experiences, learning, and contributions. It involves summarising their role, key projects, and applied skills. Interns discuss the knowledge gained, application of academic theories, and challenges faced, including how they were addressed. They reflect on their professional development and how the internship influenced their career goals. Feedback from supervisors and industry insights are also shared. Examiners ask questions to delve deeper into the intern's understanding and experiences. This evaluation assesses the intern's ability to articulate their growth and readiness for professional work. The review of the work done by students will be carried out after two weeks of report submission. The internal examiner will evaluate the student's submission.

Course Outcome:

After the course, the outcomes are as follows under

1. Application of theoretical knowledge to real-world scenarios.
2. Development of professional skills and networking opportunities.
3. I understand workplace culture and dynamics.
4. Hands-on experience in a chosen field.

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Appendix – III
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 awareness, 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 Gandhinagar 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.*

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.

IIIT Hyderabad was the first one to implement a compulsory 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.

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 choose 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 every day 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 don'ts, 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 facilities.

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

Day	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.)
	10:00 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 – 03:30 PM	Interaction with parents
	03:30 PM – 05:00 PM	Mentor-Mentee Groups - Introduction within group. (Same as Universal Human Values Group)

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.

DAY 3 Onwards

Session	Time	Activity	Remarks
	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	09:10 AM – 10:55 AM	Creative Arts / Universal Human Values	Half the groups do creative arts
III	11:00 AM – 12:55 PM	Creative Arts / Universal Human Values	Complementary Alternate Groups
	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):

Session	Activity	Remarks
IV	Familiarization with Dept./Branch & Innovations	For 3 Days (Day 3 to Day 5)
IV, V and VI	Visit to Local Area	For 3 Days – interspersed (e.g. Saturdays)

IV	Lectures by Eminent People	As scheduled 3-5 lectures
IV	Literary (Play / Literature / Book Reading)	For 3-5 Days
V	Proficiency Modules	Daily, but only for those who need it.

3.3. Closing Phase

Day	Time	Activity
Last But One Day	08:30 AM – 12:00 PM	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 extended 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 (up to 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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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.

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