COCHIN UNIVERSITY OF SCIENCE & TECHNOLOGY
KOCHI, KERALA, INDIA

SCHEME & SYLLABUS
(REVISED 2023 SCHEME)
(I – VIII Semesters)

B. TECH
IN
ELECTRONICS & COMMUNICATION ENGINEERING
(2023 & 2024 ADMISSIONS)

B.TECH. DEGREE PROGRAMME IN

ELECTRONICS & COMMUNICATION ENGINEERING

Vision

To be a supreme centre of quality Electronics Engineering education with a focus on lifelong learning, teamwork and leadership, thus creating a platform for industrial consultancy with global standards through intense research, contributing meaningfully to the development of the country.

Mission

Work with a commitment to the highest possible standards of quality in the areas of teaching, research and service
Develop a full-fledged center of learning in various fields of Electronics and Communication Engineering. Produce competent engineers adequately prepared to face challenges of the society, adhering to moral and ethical values.

Outcome Based Education

Programme Educational Objectives (PEOs):

After few years of B Tech graduation in ECE, the candidate is expected to achieve the following

PROGRAMME EDUCATIONAL OBJECTIVES:

PEO 1:

Graduates shall have core competence in mathematical, scientific and engineering domains to identify and solve engineering problems in Communication, Digital System Design, Signal Processing, Electromagnetics, Health and allied domains

PEO2:

Graduates shall excel in higher studies/research/entrepreneurship/start-up in the field of electronics and communication engineering in tune with changes in technology leading to a successful career growth.

PEO 3:

Graduates shall have professional ethics, effective communication, managerial and team work skills, to solve humanitarian issues with social and environmental commitment

PEO 4:

Graduates shall have confidence and abilities nurtured by the academic environment for promoting lifelong learning in diverse career paths and thus contribute to innovative and sustainable development.

Programme Outcomes (POs):

A graduate of this major should be able to:

1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life- long learning in the broadest context of technological change.

Programme Specific Outcomes (PSOs)

Electronics and Communication Engineering graduates will be able to

PSO1: Design, model, analyse, develop and evaluate modern electronic devices, circuits and systems for integrated communication applications with varied signal processing challenges.

PSO2: Apply suitable domain specific automation tools in the design cycle of electronic and communication systems

Program Articulation Matrix

PEO / Mission Statements	PEO1	PEO2	PEO3	PEO4
Work with a commitment to the highest possible standards of quality in the areas of teaching, research and service.	3	3	2	2
Develop a full-fledged centre of learning in various fields of Electronics and Communication Engineering	3	3	2	2
Produce competent engineers adequately prepared to face challenges of the society, adhering to moral and ethical values.	3	3	2	2

1-Slightly; 2-Moderately; 3-Substantially

Categories of Courses with the Breakup of Credits

Sl. No	Category of Courses	Credit breakup EC
1	**Humanities and Social Sciences including Management Courses** (HSMC).	**9**
2	**Basic Science courses** (BSC)	**20**
3	**Engineering Science Courses including workshop, drawing, basics of Electronics/electrical/mechanical/computer etc.,** (ESC)	**8**
4	**Professional Core Courses** (PCC)	**82**
5	**Professional elective courses relevant to chosen specialization/discipline** (PEC)	**24**
6	**Open subjects-Electives from other technical and /or emerging subjects** (OEC)	**6**
7	**Employment Enhancement Courses -Project work, seminar and internship in industry or elsewhere** (EEC)	**21**
8	**Mandatory courses [Environmental Sciences, Induction Program, Indian Constitution, Essence of Indian Knowledge Tradition]** (MC)	**(non-credit)**
	Total	**170**

Stream B: Electrical and Electronics Engineering, Electronics & Communication, Computer Science Engineering & Information Technology

SEMESTER I [Stream B]

CA – Continuous Assessment SEE – Semester End Examination

Code No.	Subject	category	L H/W	T H/W	P/D H/W	C	Marks		Total
							CA	SEE	
23-200-0101B	Calculus	BSC	3	1	0	4	50	50	100
23-200-0102B	Engineering Physics	BSC	3	0	1	3	50	50	100
23-200-0103B	Introduction to Electronic devices & Circuits	PCC	3	1	0	4	50	50	100
23-200-0104B	Introduction to Electrical Engineering	ESC	3	0	0	3	50	50	100
23-200-0105B	Computer programming	ESC	3	1	0	3	50	50	100
23-200-0106B	Soft Skills Development	EEC	2	0	0	2	50	-	50
23-200-0107B	Computer Programming Laboratory	ESC	0	0	3	1	25	25	50
23-200-0108B	Basic Electrical Engineering laboratory	ESC	0	0	3	1	25	25	50
23-200-0109B	Language Laboratory	EEC	0	0	2	1	25	25	50
23-200-0110B	NSS/Nature conservation Activities/Yoga	MC	0	0	1	0	-	-	-
	TOTAL		**17**	**3**	**10**	**22**			

SEMESTER II (STREAM B)

Code No.	Subject	category	L H/W	T H/W	P/D H/W	C	Marks		Total
							CA	SEE	
23-200-0201B	Linear Algebra & Transform Techniques	BSC	3	1	0	4	50	50	100
23-200-0202B	Engineering Chemistry	BSC	3	0	1	3	50	50	100
23-200-0203B	Digital Electronics	PCC	3	1	0	3	50	50	100
23-200-0204B	Object Oriented Programming in C++	PCC	3	1	1	4	50	50	100
23-200-0205B	Introduction to Cyber Physical Systems	PCC	3	1	0	3	50	50	100
23-200-0206B	Environmental and Life Sciences	HSMC	3	0	0	3	50	50	100
23-200-0207B	Digital Electronics Lab	PCC	0	0	3	1	25	25	50
23-200-0208B	Basic Electronics Lab	PCC	0	0	3	1	25	25	50
	TOTAL		**18**	**4**	**8**	**22**			

SEMESTER III

Code No.	Subject	category	L H/W	T H/W	P/D H/W	C	Marks		Total
							CA	SEE	
23-200-0301B*	Differential Equations and Complex Variables	BSC	3	1	0	3	50	50	100
23-203 -0302	Network Theory	PCC	3	1	0	3	50	50	100
23-203 -0303	Electronic Circuits	PCC	3	1	0	3	50	50	100
23-203 -0304	Digital System Design	PCC	3	1	0	3	50	50	100
23-203-0305	Microprocessors and Microcontrollers	PCC	3	1	0	3	50	50	100
23-203 -0306	Solid State Devices	PCC	3	1	0	3	50	50	100
23-203 -0307	Electronic Circuits Laboratory	PCC	0	0	3	1	25	25	50
23-203 -0308	Digital Systems & Programming Laboratory	PCC	0	0	3	1	25	25	50
23-203 -0309	Internship-1	EEC	0	0	1	1	50		50
	TOTAL		**18**	**6**	**6**	**21**			
Minor									
23-203-0310	Principles of Communication		3	1	0	3	50	50	100

*Common for EEE, EC, CS and IT branches

Internship-I is of a minimum duration of two weeks (10 working days) after second semester and the evaluation will take place during the third semester. For Lateral entry students, a mini project carried out can be considered equivalent to Internship-I.

SEMESTER IV

Code No.	Subject	category	L H/W	T H/W	P/D H/W	C	Marks		Total
							CA	SEE	
23-200-0401B*	Numerical and Statistical Techniques	BSC	3	1	0	3	50	50	100
23-203 -0402	Analog integrated Circuits	PCC	3	1	0	3	50	50	100
23-203 -0403	Signals & Systems	PCC	3	1	0	3	50	50	100
23-203 -0404	Electromagnetic Theory	PCC	3	1	0	3	50	50	100
23-203 -0405	Introduction to Communication Engineering	PCC	3	1	0	3	50	50	100
23-203 -0406	Python for Machine Learning Applications	PCC	2	0	2	2	100		100
23-200 -0407**	Universal Human Values	HSMC	2	1	0	3	25	25	50
23-203 -0408	Mini Project	EEC	1	0	3	2	25	25	50
23-203 -0409	Analog Integrated Circuit Laboratory	PCC	0	0	3	1	25	25	50
	TOTAL		**21**	**6**	**6**	**23**			
MINOR									
23-203 -0410	Signal Processing		3	1	0	3	50	50	100
23-203 -0411#	MOOC 1 –Broad area: Sensors and Actuators		0	0	0	3	0	0	100
HONORS									
23-203-0412#	MOOC 1: Microelectronic fabrication process		0	0	0	3	0	0	100

*Common for EEE, EC, CS and IT branches; **Common for all branches

#Students should take Massive Open Online Courses (MOOCs) of minimum 3 credits approved by the concerned Division/Board of Studies (BoS). Evaluation Pattern for UHV will be same as laboratory course.

SEMESTER V

Code No.	Subject	category	L H/ W	T H/ W	P/D H/W	C	Marks		Total
							CA	SEE	
23-203 -0501	Embedded Systems	PCC	3	1	0	3	50	50	100
23-203 -0502	Microwave Engineering	PCC	3	1	0	3	50	50	100
23-203 -0503	Digital Communication Engineering	PCC	3	1	0	3	50	50	100
23-203 -0504	VLSI design	PCC	3	1	0	3	50	50	100
23-203 -0505	Digital Signal Processing	PCC	3	1	0	3	50	50	100
23-203 -05**	Professional Elective I **$$**	PEC	3	1	0	3	50	50	100
23-203 -0510	Digital Signal Processing Laboratory	PCC	0	0	3	1	25	25	50
23-203 -0511	Communication Laboratory	PCC	0	0	3	1	25	25	50
23-203 -0512	Internship-II	EEC	0	0	1	1	50	-	50
	TOTAL		**15**	**5**	**6**	**21**			
MINOR									
23-203 -0513	Mini Project		0	0	3	3	0	0	100
23-203 -0514#	MOOC 2 –Broad area: Embedded Systems		0	0	0	3	0	0	100
HONORS									
23-203-0515	Low Power VLSI		3	1	0	3	50	50	100

Internship-II of a minimum duration of two weeks (10 working days) after fourth semester and the evaluation will take place during the V semester.

Students shall take one mandatory Massive Open Online Courses (MOOCs) during the course of time approved by the concerned Division/Board of Studies (BoS).

$$ - For 2023 admission, Professional Elective –1 (MOOC) transferred to VII semester

$$- For 2024 admission, Professional elective will be classroom learning.

23-203-0506 to 23-203-0509 Professional Elective – I	
Code No.	
23-203-0506(IE)	FPGA Based System Design using Verilog HDL
23-203 -0507	Power Electronics
23-203 -0508	Computer Organization and Architecture
23-203 -0509	Optical Fiber Communication

SEMESTER VI

Code No.	Subject	category	L H/W	T H/W	P/D H/W	C	Marks		Total
							CA	SEE	
23-203 -0601	Information theory and Coding	PCC	3	1	0	3	50	50	100
23-203 -0602	Digital Image Processing	PCC	3	1	0	3	50	50	100
23-203 -0603	Control System	PCC	3	1	0	3	50	50	100
23-203 -0604	Antenna Theory	PCC	3	1	0	3	50	50	100
23-203 -06**	Professional Elective – II	PEC	3	1	0	4	50	50	100
23-203 -06**	Professional Elective – III	PEC	3	1	0	3	50	50	100
23-203 -0613	Minor Project based on embedded systems	EEC	0	0	3	2	25	25	50
23-203 -0614	Microwave Engineering Laboratory	PCC	0	0	3	1	25	25	50
	TOTAL		**18**	**6**	**6**	**22**			
MINOR									
23-203 -0615#	MOOC 3 –Broad area: Machine Learning		0	0	0	3	100		100
HONORS									
23-203-0616	Digital Image Forensics		3	1	0	3	50	50	100
23-203-0617#	MOOC 2: Circuit Analysis for analog designers		0	0	0	3	0	0	100

#Students should take Massive Open Online Courses (MOOCs) of minimum 3 credits approved by the concerned Division/Board of Studies (BoS).

23-203-0605 to 23-203-0608 Professional Elective – II	
Code No.	Subject
23-203-0605(IE)	Introduction to Machine Learning
23-203 -0606	Satellite Communication
23-203 -0607	Flexible Electronics
23-203 -0608	Electronic Measurements & Instrumentation

23-203-0609 to 23-203-0612 Professional Elective – III	
Code No.	Subject
23-203 -0609	Advanced Digital System Design
23-203 -0610	Communication Systems
23-203 -0611	Non-Conventional Sources of Energy
23-203 -0612	MEMS and NEMS

SEMESTER VII

Code No.	Subject	category	L H/W	T H/W	P/D H/W	C	Marks		Total
							CA	SEE	
23-200 -0701*	Principles of Management	HSMC	3	1	0	3	50	50	100
23-203 -0702	Wireless Communication	PCC	3	1	0	4	50	50	100
23-203 -07**	Professional Elective – IV	PEC	3	1	0	4	50	50	100
23-203 -07**	Professional Elective – V	PEC	3	1	0	3	50	50	100
23-203 -07**	Open Elective I(MOOC)$$	OEC	3	0	0	3	50	50	100
23-203 -0714	Entrepreneurship Development	EEC	0	0	2	1	50	-	50
23-203 -0715	Seminar	EEC	0	0	3	1	25	25	50
23-203 -0716	Project phase I	EEC	0	0	6	2	25	25	50
23-203 -0717	Internship-III	EEC	0	0	1	1	50		50
	TOTAL		**15**	**4**	**11**	**22**			
HONORS									
23-203-0718	Radar Signal Processing		3	1	0	3	50	50	100
23-203-0719#	MOOC 3: Wireless Sensor Networks		0	0	0	3	0	0	100

* Common for EEE, EC, CS and IT branches

Internship-III of a minimum duration of two weeks (10 working days) after VI semester and the evaluation will take place during the VII semester.

Open Elective: The students shall select at least one Open Elective course from a domain outside their parent branch of study with prior approval from their parent division.

#Students should take Massive Open Online Courses (MOOCs) of minimum 3 credits approved by the concerned Division/Board of Studies (BoS).

$$- For 2023 admission open elective is classroom learning, (LH/W -3) and mark split up is 50 marks for CA and 50 marks for SEE
$$ -For 2024 admission open elective is MOOC. Marks will be out of 100 as per MOOC regulations

23-203 -0703 to 23-203 -0706 Professional Elective – IV	
Code No.	Subject
23-203-0703(IE)	IoT based System Design
23-203 -0704	Computational Electromagnetics
23-203 -0705	Device Modelling
23-203 -0706	Adaptive Signal Processing

23-203 -0707 to 23-203 -0710 Professional Elective –V	
Code No.	Subject
23-203-0707	Digital Integrated Circuit Design
23-203 -0708	Deep learning for Computer Vision
23-203 -0709	5G Communication Techniques
23-203 -0710	RF Circuit Design

23-203 -0711 to 23-203 -0713 Open Elective – I (OFFERED FOR 2023 ADMISSION)	
Code No.	Subject
23-203 -0711	Designing with ARM Microcontroller
23-203 -0712	Electronic Product Design
23-203 -0713	Intellectual Property Rights

23-203 -0700 Open Elective – I (MOOC) FOR 2024 ADMISSION
The student shall select at least one Open Elective course from a domain outside their parent branch of study with prior approval by the parent division. The following list shows possible non exhaustive broad areas. Students may get prior approval from the division before registration. **BROAD AREA**
Intellectual Property Rights
Finance Management
Technical Writing and Communication
Ethics and Professionalism
Sustainable Engineering
Engineering Mechanics
Material Science
Foreign Language
Environmental Science
Mathematics

SEMESTER VIII- Regular Track

Code No.	Subject	category	L H/W	T H/W	P/D H/W	C	Marks		Total
							CA	SEE	
23-203-08**	Professional Elective VI	PEC	3	1	0	4	50	50	100
23-203-08**	Professional Elective VII	PEC	3	1	0	3	50	50	100
23-20*-08**	Open Elective II	OEC	3	1	0	3	50	50	100
23-203-0813	Project phase II	EEC	0	0	18	6	200	-	200
23-203-0814	Comprehensive Viva Voce	EEC	-	-	0	1	-	50	50
	TOTAL		**9**	**3**	**18**	**17**			

SEMESTER VIII- Internship Track

Code No.	Subject	category	L H/W	T H/W	P/D H/W	C	Marks		Total
							CA	SEE	
23-203-08**	Professional Elective VI	PEC	3	1	0	4	50	50	100
23-203-0813	Project phase II	EEC	0	0	18	6	200	-	200
23-203-0814	Comprehensive Viva Voce	EEC	0	0	0	1	-	50	50
23-203-0815	Internship-IV	EEC	0	0	-	6	200	-	200
	TOTAL		**3**	**1**	**18**	**17**			

23-203 -0801 to 23-203 -0804 Professional Elective – VI	
Code No.	Subject
23-203 -0801	Computer Communication and Networking
23-203 -0802	Systems Engineering
23-203 -0803	Neuro-Fuzzy Systems
23-203 -0804	Memory and Interconnects

23-203-0805 to 23-203-0808 Professional Elective – VII	
Code No.	Subject
23-203-0805	Multimedia Communication System
23-203-0806	Electromagnetic Interference and Compatibility
23-203-0807	ASIC Design
23-203-0808	Electric Vehicle Design

23-203-0809 to 23-203-0812 & 23-200-0817 Open Elective – II	
Code No.	Subject
23-203-0809	Artificial Intelligence & Robotics
23-203-0810	Multirate signal processing
23-203-0811	Optimization Techniques & Algorithm
23-203-0812	Bio-Informatics
23-200-0817*	Constitutional Law

*Common to all branches

List of Courses for Minor in Electronics

Code No.	Subject	L H/W	T H/W	P/D H/W	C	Marks		Total Marks	Offering Semester	Mode of Learning
						CA	SEE			
23-203 -0310	Principles of Communication	3	1	0	3	50	50	100	S3	Classroom
23-203 -0410	Signal Processing	3	1	0	3	50	50	100	S4	Classroom
23-203 -0411	MOOC 1 –Broad area: Sensors and Actuators	0	0	0	3	0	0	100	S4	Online
23-203 -0513	Mini Project	0	0	0	3	0	0	100	S5	
23-203 -0514	MOOC 2 –Broad area: Embedded Systems	0	0	0	3	0	0	100	S5	Online
23-203 -0615	MOOC 3–Broad area: Machine Learning	0	0	3	3	100		100	S6	Online

List of Courses for Honors

Code No.	Subject	L H/W	T H/W	P/D H/W	C	Marks		Total Marks	Offering semester	Mode of Learning
						CA	SEE			
23-203-0412	MOOC 1: Microelectronic fabrication process	0	0	0	3	0	0	100	S4	Online
23-203-0515	Low Power VLSI	3	1	0	3	50	50	100	S5	Classroom
23-203-0616	Digital Image Forensics	3	1	0	3	50	50	100	S6	Classroom
23-203-0617	MOOC 2: Circuit Analysis for analog designers	0	0	0	3	0	0	100	S6	Online
23-203-0718	Radar Signal Processing	3	1	0	3	50	50	100	S7	Classroom
23-203-0719	MOOC 3: Wireless Sensor Networks	0	0	0	3	0	0	100	S7	Online

Industry based Electives:
Industry based Electives are offered in 6th and 7th Semesters and are listed among the Professional Electives with notation (IE) along with the subject code. A student should opt for at least one Industry based elective during the B.Tech. programme.

Open Electives:
Open Electives are offered in 7th and 8th Semesters. The students shall select at least one Open Elective course from a domain outside their parent branch of study with prior approval from their parent division.

MOOC:
Every student shall undergo at least one MOOC of minimum 3 credits during the programme (preferably before the final semester) as per the University regulations for conducting online courses (MOOC). If the MOOC specified in the scheme is not available during the semester, division may approve an equivalent MOOC from the list of NPTEL/SWAYAM or any other agencies approved by the University.

Minor Course:
Amendments in regulations of revised 2023 scheme applicable in respect of minor courses.

Semester VIII Internship Track

Students who intend to go for internship track should inform the division head concerned before the commencement of 8th semester. The students will be given an option to change the track within 30 days from the commencement of 8th semester.

Students opting for Internship Track have to do Project-Phase – II and appear for the Comprehensive Viva- Voce.

The interns may opt for courses recommended by the division from the list of NPTEL/SWAYAM courses or any other agencies approved by the university.

The students opting for divisional courses have to fulfill the requirements of continuous assessment and semester end examination.

Project-phase –II is the continuation of Project-phase –I completed in the seventh semester or a separate one if approved by the division.

The Internship -IV of minimum 6 weeks' duration must be done in an industry approved by the Placement Cell or respective Division based on a valid MoU or in any reputed organization approved by the division.

The Internship-IV is equivalent to two 3-credit courses of total 200 marks

The progress of Internship-IV will be evaluated twice during the semester, along with the internal examinations and finally after the completion of the internship.

Special Option for Outstanding Students

This Special Option for Outstanding Students (SOOS) enables outstanding students having CGPA 9.0 or above (CGPA up to and including IV semester) with no history of backlogs to successfully complete the mandatory elective/s earmarked for the VIII semester during the VI and VII semesters itself by making use of the equivalent MOOCs with the necessary prior approval by the concerned Division. This SOOS enables outstanding students to fully concentrate on the project/internship during the VIII semester.

The interested candidates meeting the eligibility criteria as mentioned above shall apply for the SOOS immediately after the IV semester results got published.
The Department/Division shall scrutinize the applications received for the SOOS and shall publish the list of students eligible for the same along with the details of the MOOCs equivalent to the VIII semester electives within 15 days.

The certificates of successful completion of all the relevant VIII semester elective course/s shall be submitted by the student to the University within the stipulated time.ie., before the beginning of the VIII semester.

If the student fails to submit the certificates as mentioned above or not interested in utilizing the SOOS, he/she has to undergo VIII semester using the regular/internship track as mentioned in the B. Tech scheme.

Evaluation Pattern for Theory and Practical courses

1. **Theory courses**

   Type of Questions for Semester End Examination (SEE)

   PART - A (5 x 2 = 10 marks)

   Question No. I (a) to (e) –Five short answer questions of 2 marks each with at least one question from each of the four modules.

   PART - B (4x10 = 40 marks)

   Question nos. II and III (from Module I) of 10 marks each with option to answer either II or III. The question may have sub sections (a) and (b)

   Question nos. IV and V (from Module II) of 10 marks each with option to answer either IV or V. The question may have sub sections (a) and (b).

   Question nos. VI and VII (from Module III) of 10 marks each with option to answer either VI or VII. The question may have sub sections (a) and (b).

   Question nos. VIII and IX of 10 marks each with option to answer either VIII or IX. The question may have sub sections (a) and (b)

   The maximum marks that can be awarded for the Semester End Examination (SEE) will be 50.

2. **Practical courses**

   50% marks is earmarked for Continuous Evaluation, and 50% marks for Semester End Examination. The Semester End Examination to be conducted by a minimum of two examiners.

3. **Pass Requirements**
   A candidate has to obtain a minimum of 50% marks for continuous assessment and semester end examination put together with a minimum of 40% marks in the semester end examination for a pass

in theory and laboratory courses.
In the case of theory/laboratory/other courses having only continuous assessment, a candidate has to obtain a minimum of 50% marks in continuous assessment for a pass.

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SEMESTER I

23-200-0101B CALCULUS

Course Outcomes:
On completion of this course the student will be able to:

1. Solve ordinary differential equations and linear differential equations of higher orders with constant coefficient and apply them in engineering problems

2. Determine the maxima and minima of multi variable functions.
3. Convert line integrals into surface integrals and surface integrals into volume integrals
4. Illustrate the physical meaning and application of gradient, divergence and curl.

CO PO PSO Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	3	2	2										3	
CO2	3	2	1										2	
CO3	3	2											3	
CO4	3	3	1										2	3

1-Slightly; 2-Moderately; 3-Substantially

Module I

Ordinary differential equations:

First order differential equations - exact differential equations, Bernoulli's equations--Methods of solution and Simple applications.

Linear differential equations of higher orders with constant co-efficient-Methods of solution of these equations. Cauchy's linear differential equations. Simultaneous linear differential equations- Simple applications of linear differential equations in engineering problems –Electrical Circuits, Mechanical Systems.

Module II

Partial differentiation: Partial differentiation-Concept of partial derivative - Chain rule- Total derivative- Euler's theorem for homogeneous functions, Differentials and their applications in errors and approximations, Jacobians - Maxima minima of functions of two variables (Proof of the result not required)-Simple applications.

Co-ordinate systems: Rectangular co-ordinates-Polar co-ordinates-In plane and in Space-Cylindrical polar co-ordinates-Spherical polar co-ordinates.

Module III

Integral calculus:

Application of definite integrals: Area, Volume, Arc length, Surface area.

Multiple integral: Evaluation of double integrals-Change of order of integration. Evaluation of triple integrals-Change of Variables in integrals.

Applications of multiple integrals. Plane Area, Surface area & Volumes of solids

Module IV

Vector calculus: scalar and vector point functions, gradient and directional derivative of a scalar point function, divergence and curl of vector point functions, their physical meaning. Evaluation of line integral, surface integral, and volume integrals, Gauss's divergence theorem, Stoke's theorem (No proofs), conservative force fields, scalar potential.

Textbooks:

1. Erwin Kreyzig. *Advanced Engineering Mathematics* John Wiley& Sons, Hoboken, NJ, 10/e, (2011)
2. Grewal, B.S. *Higher Engineering Mathematics,* Khanna Publishers, New Delhi, 43/e (2013).

References:

3. Sastry, S.S. *Engineering Mathematics: Vol1*. PHI Learning, New Delhi, 4/e (2008).
4. Veerarajan, T. *Engineering Mathematics*. Tata McGraw Hill Publishers, New Delhi. 3/e (2011)

23-200-0102B ENGINEERING PHYSICS

Course Outcomes:

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

1. Interpret modern devices and technologies based on lasers and optical fibres.
2. Explain the basic principles of crystal physics
3. Summarise the characteristics and applications superconducting materials nanomaterials and smart materials
4. Illustrate the theory of semiconductors and magnetic materials
5. Understand the principle, concept, working and applications of relevant technologies and comparison of results with theoretical calculations.

CO PO PSO Articulation Matrix:

	PO1	PO2	PO3	PO 4	PO5	PO6	PO7	PO8	PO9	PO10	PO1 1	PO12	PSO 1	PSO 2
CO1	3	2	2										2	
CO2	3	1	1										2	
CO3	3	2	1										2	
CO4	2	2	2										3	
CO5	3	2	2										2	2

1-Slightly; 2-Moderately; 3-Substantially

Module I

Laser-properties-interaction of radiation with matter-absorption, spontaneous and stimulated emission- principle of laser--Einstein coefficients- population inversion- metastable state -Basic components of a laser- construction and working of Ruby laser and He-Ne laser -Applications.

Fibre optics - Basic structure - principle- step-index fibre and graded index fibre- single mode and multimode- Numerical aperture (no derivation) -acceptance angle and acceptance cone-propagation- Applications.

Module II

Crystallography – Space lattice- Basis- Unit cell-Bravais lattices- cubic lattices-sc, bcc, and fcc- Number of atoms per unit cell- Coordination number- Atomic radius-Packing factor- Relation between density and crystal lattice constants- Lattice planes and Miller indices.

X-rays- Production, Properties, characteristic and continuous X-rays, Moseley's law; Diffraction of X-rays- Bragg's law (derivation), Bragg's Spectrometer

Module III

Superconductor-transition temperature-Meissner effect-effect of current- isotope effect- Type 1 and type 2 superconductors –BCS theory (basic idea only)- Applications.

Nanomaterials- nanoparticle, nano ring, nano rod, nanoshells, fullerene- surface occupancy-quantum confinement effect-optical, electrical, magnetic and mechanical properties - Applications.

Smart materials-Liquid crystals, Metallic glasses, Shape memory alloys- optical, electrical magnetic and mechanical properties-applications.

Module IV

Magnetic Materials-Magnetic pole strength, magnetic moment, intensity of magnetization, magnetic field, magnetic induction, magnetic susceptibility, magnetic permeability, classification. Hard and soft- Paramagnetic materials-properties, Diamagnetic materials-properties, Ferromagnetic properties- Antiferromagnetic materials, Ferrimagnetic materials-Applications

Semiconductor Physics and Devices:
Intrinsic semiconductor, Intrinsic carrier concentration, Variation of Intrinsic carrier concentration with temperature, Extrinsic semiconductor (qualitative), Fermi level in semiconductors-intrinsic and extrinsic, Formation of p-n junction, Energy band diagram of p-n junction - Qualitative description of charge flow across a p-n junction - Forward and reverse biased p-n junctions, I-V Characteristics of p-n junction diode, Solar cells- IV Characteristics, Light Emitting Diode, Zener diode VI characteristics, Tunnel diode-VI characteristics. Semiconductor devices- Rectifiers-Full wave and Half wave.

Laboratory Experiments to be conducted in the virtual lab mode List of Experiments (Minimum six experiments shall be conducted)

1. Transmission grating: To find the wavelength of laser beam
2. Determination of NA of an optical fibre
3. Laser beam divergence and spot size
4. Determination of Grain size and lattice parameter using Bragg's X-ray spectrum
5. Lattice planes from X Y Z intercepts
6. LCR circuits to find the resonance frequency and quality factor.
7. Diode characteristics
8. Ohm's law
9. LED circuits to find cutting voltage.
10. Determination of Energy band gap of a given semiconductor material
11. Magnetic field along the axis of a circular coil carrying current
12. Deflection Magnetometer

Text books:

1. B Premlet, *Advanced Engineering Physics*, Phasor publication, 10/e (2017), ISBN: 52301010102
2. A Nahari, Sini Chandran, *Physics for Engineers*, Owl publications, ISBN 978-93-92321-32-0

References:

1. S. Mani Naidu, A Textbook of Engineering Physics, Pearson. (2010)
2. A.S. Vasudeva, Modern Engineering Physics, S. Chand & Co. (2013)
3. Prabir K. Vasu and Hrishikesh Dhasmana, Engineering Physics, Ane books Pvt. Ltd. (2010)
4. S.O. Pillai and Sivakami, Applied Physics, New Age International (P) Ltd., Second Edition. (2008)
5. G.S. Raghuvanshi, Engineering Physics, Prentice Hall of India. (2008)

Pattern of Continuous Assessment

Test – I for the theory portions: 15 marks
Test -II for the theory portions: 15 marks
Assignment from the theory portions: 5 marks
Laboratory record and Viva-voce: 10 marks (5 + 5)
Attendance: 5 marks

The students are required to submit the laboratory record.

23-200-0103B INTRODUCTION TO ELECTRONIC DEVICES & CIRCUITS

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student will be able:

1. To understand the working principle of various semiconductor devices
2. To apply the acquired knowledge to the use of semiconductor devices in various applications.
3. To design simple electronic circuits for a given application.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	2	3	2									1	3	1
CO2	2	2	2									1	2	2
CO3	1	3	1	1								1	3	3

1-Slightly; 2-Moderately; 3-Substantially

Module I:

Semiconductor basics. PN junction diode and its characteristics, Diode Models Diode Applications: Rectifiers- Half wave and full wave rectifiers, Capacitive Filter Clipping and clamping circuits, Special purpose diode: Zener Diode, LED, Photo diode; Zener Shunt, Transistor series regulator

Module II:

Bipolar Junction Transistors (BJT): Transistor Structure, Transistor operation, Transistor characteristics (CE & CB only) and alpha & beta Parameters, r parameter model, h parameter Transistor as an amplifier, Transistor bias circuits: DC operating point, load line, stabilization, Voltage divider bias, Thermal runaway. Transistor switch. FET, FET characteristics

Module III:

Amplifiers: classification of amplifiers as Voltage, Current, transconductance & transresistance amplifiers-properties, operation, CB, CC & CE Amplifiers, bypass and coupling capacitor, common emitter Amplifier, Amplifier Frequency Response: Basic concepts, Low frequency and High frequency response cutoff Total Amplifier frequency Response. FET amplifier (CS configuration only), Multistage amplifier (qualitative study).

Module IV:

Feedback in amplifier, benefits of feedback, positive & negative feedback (qualitative study). Oscillator : RC phase shift oscillator, circuit & its working. LC oscillator Multivibrator: astable multi vibrator, circuit & its working. Bistable multi vibrators, circuit & its working. bistable as memory.

Text book:

1. David M. Buchla, Thomas L. Floyd, *Electronics Fundamentals, Circuits, Devices and Applications*, Pearson Education Limited, 8/e (2014) ISBN 978-1-292-02568-1

References:

2. K V Ramanan, *Functional Electronics*, Tata McGraw-Hill Publishing Company Ltd. (1984).
3. Donald Neamen, *Semiconductor Physics and Devices*, Tata McGraw-Hill Publishing Company Ltd., 4th edition (2021).
4. Jacob Milman, Christos C Halkias, *Integrated Electronics: Analog and Digital Circuits and Systems*, McGraw Hill Education, 2/e (2017).

23-200-0104B INTRODUCTION TO ELECTRICAL ENGINEERING

Course Outcomes

1. Apply elementary principles for finding the DC response of Circuits.
2. Develop & solve models of basic magnetic & electromagnetic circuits.
3. Apply elementary principles for finding the sinusoidal steady state features of Circuits.
4. Familiarize with the basic engineering principles of some common electrical systems.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	2	3	2									1	2	
CO 2	2	2	2									1	3	
CO 3	1	3	1	1		1						1	3	
CO 4	2	1	1			2						1	2	

1-Slightly; 2-Moderately; 3-Substantially

MODULE I: Elementary Concepts of Electric Circuits Elementary concepts of DC electric circuits: Basic Terminology including voltage, current, power, resistance, emf; concept of linear, non linear, unilateral, bilateral, active & passive circuit elements, independent voltage & current sources, Interconnection of Resistances- series, parallel, series-parallel, star & delta interconnection, Star-delta/delta-star transformation ; Current and Voltage Division Rules; Capacitance: Parallel plate capacitance with single dielectric, V-I relations and energy stored, Capacitances in series, parallel & series-parallel; Ohm's Law and Kirchhoff's laws-Problems.

Introduction to Dynamic Circuits: DC Sourced & Source free Response of RC series circuit, Time Constant, Concept of transient & steady state components of response.

MODULE II: Elementary Concepts of Magnetic & Electromagnetic Circuits, and AC fundamentals

Magnetic Circuits: MMF, field strength, flux density, reluctance - comparison between electric and magnetic circuits- Series and parallel magnetic circuits with composite materials, numerical problems.

Electromagnetic Induction: Faraday's laws, Lenz's law- statically induced and dynamically induced emfs, conductor moving in a uniform magnetic field, Self-inductance and mutual inductance, coefficient of coupling, V-I relations of self & mutual inductance, Two winding Transformer, Basic Transformer Equation connecting voltages, currents & number of turns, energy stored in a coupled coil system, Series Connection of coupled Inductances.

Alternating Current fundamentals: Representation of sinusoidal waveforms: frequency, period, cycle, phase, Average, RMS values and form factor of waveforms-Numerical Problems.

MODULE III: Sinusoidal Steady State Response

Sinusoidal Steady Response of Basic Elements: Phasor Representation of sinusoidal quantities, Trigonometric, Rectangular, Polar and complex forms, Response of basic R, L and C elements to a sinusoidal voltage or current –Phasor diagrams, Average power and power factor-Numerical Problems.

Series and Parallel AC Circuits: Reactances, Impedance, Admittance, Solution of series, parallel & series-parallel AC circuits, Power in AC circuits: active, reactive & apparent powers-Numerical Problems, Resonance in series and parallel circuits, Frequency dependance of impedance and admittance, frequency response function & frequency response plots, half power/cut off frequency, bandwidth

Three phase AC systems: Star and delta connected balanced three phase systems, Phasor diagram, relation between line and phase voltages, line and phase currents, active, reactive & apparent powers-Numerical problems

MODULE IV: Applications

Dynamic Circuits: Use of simple first & second order resonant/non resonant RLC circuits as low pass, high pass, band pass & band stop filters, RC Differentiator & Integrator

Power Circuits of domestic/Daily Use Appliances: Concept of Linear & non linear AC loads, very basic concept of Power Quality, Functional Block Diagram of the power circuit of modern domestic/daily use appliances-LED Lamps & Tubes, BLDC Fans, Mobile & Laptop Chargers, Inverter Air Conditioner & Inverter Refrigerator, Need & methods of galvanic isolation.

Rechargeable Batteries: Basic Terminology, Battery Capacity, SOC, SOE, SOH DOD, C-rate, Cycle Life, Cut off voltage, deep cycle, Charging Profile, self discharge, Energy Density, Power density, Specific Energy, Specific Power, Purpose & Functions of BMS.

UPS: Functional block diagram, Specifications and Applications of online & offline UPS, computation of back up time.

Power Systems: Various levels of Power Transmission/Distribution- Typical Single line diagram

Text books:

1. Edward Hughes. *Electrical technology*. Pearson Education 8th ed. 2002.
2. Robert L. Boylestad. *Introductory circuit analysis*. Pearson Education, 14th edition 2022

References

3. Cotton, H. Electrical technology. CBS Publishers and Distributors, New Delhi. 7th edition
4. Leonard S. Bobrow. Fundamentals of electrical engineering. Oxford University Press. second edition, 1996

23-200-0105B COMPUTER PROGRAMMING

Course Outcomes:

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

1. Identify main components of a computer system and explain its working.
2. Develop flowchart and algorithms for computational problems.
3. Write the syntax of various constructs of C language.
4. Build efficient programs by choosing appropriate decision-making statements, loops and data structures.
5. Design modular programs using functions for larger problems.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3											1	2	2
CO2	2	2	3		2							1	2	
CO3	3											1	2	2
CO4	3	3	3		3							2	3	3
CO5	3	3	3		2	2						2	2	3

1-Slightly; 2-Moderately; 3-Substantially

Module I

Basics of Computer and Information Technology: Digital Computer System (CPU, Memory, I/O devices)- Working of a digital computer-Hardware and Software: Definition - Categories of Software, Application of Computers.

Problem Solving Methodology: Problem statement, Analysis, Design a solution, Implement/Coding the solution, Test the solution, Design tools (Algorithm, Flow-chart, Pseudo- code)- Develop algorithms for simple problems.

Programming Languages:Types of Languages-Compiler–Interpreter-Linker–Loader– Execution of program.

Module II

Basics of C: Character set-Identifier- Keywords- Constants –Data Types- Variables and declaration –Operators and Expressions – Operator precedence and associativity – Expression Evaluation (Simple Examples) - Input and output functions – Simple computational problems involving the above constructs.

Control Statements: Selection, Conditional operator, Iteration (for, while, do-while), Branching (switch, break, continue, goto), Nesting of control statements- Problems using control statements.

Module III

Arrays: One-dimensional array: Declaration, Initializing and Accessing of Array, Operations with Array, Internal Representation of Array, Working with One-dimensional Array (searching and sorting).

Multi-dimensional array: Declaration, Initializing and Accessing of Array, Working with Two- dimensional Arrays with Matrix.

Strings: Declaration, Initialization and Accessing of String, String Functions, Working with One-dimensional character Array and String Functions.

Functions: Concept of Function, Using Function (Declaration, Definition and Calling), Parameter Passing in C, Inline Function, Recursion, Working with Functions.

Module IV

User defined data types: Structure, Union & Enumerated data type- Declaration, Initialization and Accessing of Structure, Union & Enumerated Data types, Structure versus Union, Arrays of Structure, Working with Structures.

Pointers: Declaration, Initialization & Accessing Pointer– Use of Pointers, Pointer Arithmetic, Arrays and Pointers, Structures and Pointers, Working with Pointers (Pointers to Array: One- dimensional arrays and pointers, Passing an array to a function), Dynamic memory allocation. Command line arguments.

Text book:

1. Pradip Dey and Manas Ghosh, *Computer Fundamentals and Programming*, 2/e, Oxford University Press, (2013).

References:

2. Byron Gottfried, *Programming with C*, 4/e, Tata McGraw-Hill, (2018).
3. Brian W. Kernighan and Dennis M. Ritchie, *The C Programming Language*, 2/e, Pearson Education, (2015).
4. R.G. Dromey, *How to solve it by Computer*, Pearson Education, (2008).
5. Kanetkar Y, *Let Us C:Authentic guide to C programming language* 18/e, BPB Publications, (2021).

23-200-0106B SOFT SKILLS DEVELOPMENT

Course Outcomes:

On completion of this course the student will be able to:
CO1: Use English language at the formal and informal levels for daily conversations, presentations, group discussions and debates.
CO 2: Demonstrate the ability to read, comprehend and answer questions based on literary, scientific and technological texts.
CO 3: Develop self-motivation, raised aspiration, belief in one's own abilities and commitment to achieving one's goal.
CO 4: Demonstrate emotional maturity and emotional health.

CO PO PSO Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2
CO 1						1		2	2	3			3	
CO 2						2		2	2	3			2	1
CO 3						1		2	2	2			2	
CO 4						1		2	3	2			2	

1-Slightly; 2-Moderately; 3-Substantially

Module I
Role and importance of verbal communication – Everyday active vocabulary, common words used in transitions, enhancing vocabulary, affixes and changes in pronunciation and grammatical functions, words often confused in pronunciation and usage. Passage comprehension: skimming, scanning techniques, note making, note taking and summarizing. Deciphering meaning from contexts. Types of meaning: literal and contextual. Constructive criticism of speeches and explanations.

Module II
Fundamental grammar, Simple structures, passivating the active sentences, reported speech, the judicious use of tenses and moods of verbs, forming questions and conversion from questions to statements and vice versa, forming open –ended and close- ended questions. Words and style used for formal and informal communication. Practice converting informal language to formal, the diction and the style of writing. Dealing with the nuances of ambiguous constructions in language. Learning authoritative writing skills, polite writing and good netiquette. Writing for internships and scholarships.
Fundamental grammar – Simple structures, passivizing the active sentences, reported speech, the judicious use of tenses and moods of verbs, forming questions and conversion from questions to statements and vice versa, forming open-ended and close- ended questions. Words and style used for formal and informal communication. Practice converting informal language to formal, the diction and the style of writing. Dealing with the nuances of ambiguous constructions in language. Learning authoritative writing skills, polite writing and good netiquette. Writing for internships and scholarships. spherical polar co-ordinates.

Module III
Communication – Kinesics, proxemics, haptics, and other areas of non-verbal communication, fighting communication barriers, positive grooming and activities on the same. Different types of interviews and presentation: oral, poster, ppt. Organizing ideas for group discussions, the difference between GD and debates. Effective listening and seeking to understand others' perspectives. Non-violent negotiation and persuasion, communicating across age groups, cultures or identity groups. Higher order thinking and evaluation, information seeking, research, and independent learning, synthesis, creativity, problem analysis and problem solving. Decision making, self- reflection and learning from experience.

Module IV

Developing positive self – Understanding oneself, realistic awareness of oneself and one's abilities, strengths and potential, self-esteem, self-efficacy, steps for improvement. Intra-personal skills: self-control, emotional regulation and self-discipline, conscientiousness, dutifulness, reliability, truthfulness, honesty and trustworthiness. Goal orientation and initiative. Time management – characterisation work. Interpersonal skills: cross cultural competence and valuing diversity of perspectives, respecting and expressing concern for others. Empathy and ability to notice the effect of one's actions on others, tolerance for disagreement, conflict management and resolution.

Text books:

1. Duck, Steve and David T. Macmahan. Communication in Everyday Life. 3rd Ed. Sage, (2017).
2. Gamble Teri Kwal, W.Gamble Michael, The Public Speaking Playbook, 2nd Edn., Sage (2017).

References:

3. Meenakshi Raman, Sangeeta Sharma, Technical Communication: Principles and Practice, 3rd Edn., Oxford University Press (2015).
4. Daniel Goleman, Emotional intelligence: Why it can matter more than IQ, Random House (2012).
5. Devadas Menon, Stop sleep walking through life!, Yogi Impressions Books Pvt. Ltd. (2013).
6. Barun K. Mitra, Personality Development and Softskills, Oxford University Press (2012).

ASSESSMENT

1. 'Soft Skills Development' is a practical and activity-oriented course which has continuous assessment for 50 marks based on classroom interaction, activities, and assignments. The activities may include 'Just a Minute' (JAM) sessions, group discussion, role play, debate, and extempore speech.
   The weightages for the different components shall be as follows:
   Classroom interaction – 10 marks Activities – 30 marks
   Assignments (from Modules I and II) – 10 marks
2. Semester End Examination is not envisaged.
3. A student should secure a minimum of 50% marks in continuous assessment for a pass in the course.

23-200-0107B COMPUTER PROGRAMMING LABORATORY

Course Outcomes:

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

1. Write programs using loops and decision making statements in C language.
2. Implement different operations on arrays.
3. Solve problems using functions and recursion.
4. Design and implement C programs using the concepts of structure and pointers.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	2	3		2							1	2	3
CO2	3	2	1									1	2	3
CO3	3	3	3		3	1						2	2	3
CO4	3	3	3		2	1						2	3	3

1-Slightly; 2-Moderately; 3-Substantially

Cycle I

Application Packages:

Text Editor

1. To create a word document like an advertisement.

Spreadsheet

1. To create a spreadsheet to analyse the marks of the students of a class and also to create appropriate charts.

Presentation Software

1. To create a presentation for the department using MS PowerPoint.

C Programming Basics:

1. To write a program to calculate and display areas of rectangle and triangle.

Decision Making:

2. To write a program for electricity bill preparation.
3. To write a program to find the roots of a quadratic equation.
4. To write a simple menu driven calculator program using switch statements.
5. To write a program to find the sum of digits of a given number.

Cycle II Looping:

6. To write a program to print all the prime numbers of a given range.
7. To write a program to print the sine and cosine series.
8. To write a program to print Pascal's triangle.

Arrays:

9. To write a program to print the sum and average of elements in an array.
10. To write a program to sort the given numbers using bubble sort.
11. To write a program to perform Matrix addition and matrix multiplication.

String:

12. To write a program to perform string manipulation functions like string concatenations, comparison, find the length and string copy without using library functions.
13. To write a program to arrange names in alphabetical order.

Cycle III Functions:

14. To write a C program to calculate the mean, variance and standard deviation using functions.
15. To write a C program to perform sequential and binary search using functions.

Recursion:

16. To write a program to print the Fibonacci series using a recursive function.
17. To write a program to print the factorial of the given number using a recursive function.

Structure:

18. To print the mark sheet of N students using structures.

Pointers:

19. To write a program using pointers to access the elements of an array and count the number of occurrences of the given number in the array.

Text book:

1. Pradip Dey and Manas Ghosh, Computer Fundamentals and Programming in C, Second Edition, Oxford University Press, (2013).

References:

2. Smarajit Ghosh, All of C, PHI Learning Pvt. Ltd, (2009).
3. Byron Gottfried, Programming with C, Fourth edition, Tata McGraw-Hill, (2018).
4. Brian W. Kernighan and Dennis M. Ritchie, The C Programming Language, Second Edition, Pearson Education, (2015).
5. Sukhendu Dey, Debobrata Dutta, Complete Knowledge in C, Narosa PublishingHouse, New Delhi, (2013).
6. R.G. Dromey, How to solve it by Computer, Pearson Education, (2008).
7. Kanetkar Y, Let Us C:Authentic guide to C programming language (18th Edition), BPB Publications, (2021).

23-200-0108B BASIC ELECTRICAL ENGINEERING LABORATORY

Course Outcomes

1. Identify & choose appropriate apparatus for ON-OFF Control, protection diagnosis & instrumentation of a typical LV electrical appliance/circuit.
2. Familiarize with various types of electric motors and conventional & smart electrical systems.
3. Familiarize with the electrical characteristics of common appliances & solar panels.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	2	2									1	2	
CO2	2	2	3										2	
CO3	1	3	2	2					1				3	

Details of Experiments

1. Familiarization with various electrical apparatus like switches, relays, smart plugs, smart switches, conventional to smart switch converters, AC & DC Voltmeter, AC & DC Ammeter, Multimeter, Wattmeter, Energy meter, fuse, MCB, Isolator, RCB, ELCB, RCBO
2. Verification of Ohm's Law & Kirchoff's Laws for both DC & AC circuits.
3. Domestic Wiring Circuits with one way/two way switches & plug point.
4. Experimental determination of V-I characteristics, MPP & predetermination of operating point of a solar panel for resistive load.
5. Measurement of Current, Power, Power Factor & Energy of:
   a. A single phase circuit with known parameters
   b. Various domestic/daily use appliances like LED Lamps, LED Tubes, Ceiling fans, Laptop, LED Display, PC+LED Display.
6. Experimental/Simulation based study of an RLC series Circuit under resonant & non resonant conditions.
7. Experimental determination of frequency Response of Circuits.
8. Familiarization with various types of Electrical Machines
9. Experiment on Automatic Street Lighting System.
10. Experiments on Home Automation.

Text books:

1. K B Raina and S K Bhattarcharya, *Electrical Design Estimating and Costing*, new Age International Publishers, 2/e, (2017) ISBN 978-8122443585
2. M K Giridharan, *Electrical Systems Design*, I K International Publishing House Pvt. Ltd 3/e (2022)

References:

3. Edward Hughes. *Electrical technology*. Pearson Education 8th ed. 2002.
4. Robert L. Boylestad. *Introductory circuit analysis*. Pearson Education, 14th edition 2022

23-200-0109B LANGUAGE LABORATORY

Course Outcomes:

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

1. Test pronunciation skills through stress on word accent, intonation, and rhythm.
2. Use the English language effectively for writing business letters, resumes, minutes of meetings and reports.
3. Use the English language effectively to face interviews, group discussions, and public speaking.

CO PO PSO Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2
CO1									2	3		2	2	2
CO2									2	3		2	3	2
CO3									2	3		2	3	2

1-Slightly; 2-Moderately; 3-Substantially

The following exercises are prescribed for the Language Laboratory sessions:

1. Introduction to the Sounds of English- Vowels, Diphthongs & Consonants.
2. Introduction to Stress and Intonation.
3. Preparing business letters
4. Preparing a resume
5. Conducting a meeting and writing the minutes
6. Writing a report
7. Situational Dialogues / Role Play.
8. Oral Presentations- Prepared and Extempore.
9. 'Just A Minute' Sessions (JAM).
10. Describing Objects / Situations / People.
11. Debate
12. Group discussion

Text book:

Nirupa Rani, Jayasree, *Speak Well,* Orient Black Swan Publishers, (2012), ISBN 8125044655

References:

1. Jones D, *Cambridge English Pronouncing Dictionary*, Cambridge University Press India, 18/e, (2016), ISBN 978-1107685888
2. T Balasubramanian*, Textbook of English Phonetics for Indian Students,* Macmillan Publishers, 3/e, (2017), ISBN 978-9380644943

23-200-0110B NSS/NATURE CONSERVATION ACTIVITIES/YOGA

NATIONAL SERVICE SCHEME (NSS)

Course Outcomes:

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

1. Identify the community in which they work
2. Utilise their knowledge in finding practical solutions to individual and community problems.

A student enrolling as a member of NSS will have to complete 10 hours of training / social service.

NATURE CONSERVATION ACTIVITIES

Course Outcomes:

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

1. Demonstrate the message of sustainable lifestyles.
2. Explain the importance of green plants in mitigating global environmental problems.
3. Identify suitable waste management practices for the local community.

A student enrolling as a member of the Nature Conservation Club will have to complete 10 hours of campus cleaning and greening activities.

YOGA

Course Outcomes:

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

1. Demonstrate the use of yoga for stress management.
2. Illustrate the different yogic postures for physical and mental wellbeing.
3. Identify suitable methods of strengthening physical, emotional, intellectual aspects of "self" based on the principles and practices of Yoga and positive psychology.

SEMESTER II

23-200-0201B LINEAR ALGEBRA & TRANSFORM TECHNIQUES

Course Outcomes:

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

1. Solve linear systems of equations and to determine Eigen values and vectors of a matrix.
2. Exemplify the concept of vector space and subspace.
3. Determine Fourier series expansion of functions and transform.
4. Solve linear differential equation and integral equation using Laplace transform.

CO PO PSO Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	3	1											3	
CO2	3	1											2	2
CO3	3	3	3										3	
CO4	3	3	2										2	2

1-Slightly; 2-Moderately; 3-Substantially

Module I

Linear Algebra 1: Rank of a matrix, solution of linear system of equations- existence, uniqueness, general form-Eigen values and Eigen vectors- properties of Eigen values - Diagonalization of a matrix - Cayley Hamilton theorem (without proof) Verification-Finding inverse and power of a matrix using it- Quadratic form-orthogonal reduction of quadratic form to Canonical form.

Module II

Linear Algebra 2: Vector space-subspace-Linear dependence and independence-Spanning of a subspace- Basis and Dimension. Inner product- Inner product spaces - Orthogonal and Orthonormal basis
–Gram- Schmidt Orthogonalization process. Linear Transformation.

Module III

Fourier Analysis: Periodic function, Fourier series, Functions of arbitrary period, Even and odd functions, Half Range Expansion, Harmonic analysis, Complex Fourier Series, Fourier Integrals, Fourier Cosine and Sine Transform, Fourier Transform.

Module IV

Laplace Transforms: Gamma functions and Beta function-Definition and properties, Laplace transforms. Inverse Laplace Transform, Shifting theorem, Transform of Derivative and Integrals, Solution of differential equation and integral equation using Laplace transform, Convolution, Unit step function, Second Shifting theorem, Laplace transform of periodic function.

Text books:

1. Erwin Kreyzig, *Advanced engineering mathematics*. 10/e, (2010). John Wiley & Sons, Hoboken, N.J
2. Grewal, B.S, *Higher engineering mathematics*. 43/e, (2013). Khanna Publishers, New Delhi.

References:

3. Hsiung,C.Y and Mao, G. Y. (1999). *Linear algebra*. World Scientific, New Jersey.
4. Hoffman, K. and Kunze, R. (1971). *Linear algebra*. Prentice Hall of India, New Delhi.
5. Venkataraman, M. K. (1999). *Linear algebra*. The National Publishing Co, Chennai.

23-200-0202B ENGINEERING CHEMISTRY

Course Outcomes:

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

1. Explain the basic concepts of chemical thermodynamics, and quantum chemistry.
2. Illustrate the spectroscopic methods in characterizing materials.
3. Develop electrochemical methods to protect different metals from corrosion.
4. Interpret the chemistry of a few important engineering materials and their industrial applications.
5. Understand the principle, concept, working and applications of relevant technologies and comparison of results with theoretical calculations.

CO PO PSO Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	2	3	2										2	
CO2	3	2	3										2	2
CO3	1	1	1										2	
CO4	1	1	1										2	
CO5	2	2	3										2	2

1-Slightly; 2-Moderately; 3-Substantially

Module I

Chemical Thermodynamics: Fundamentals. First law of thermodynamics, Molecular interpretation of internal energy, enthalpy and entropy. Heat of reaction. Kirchoff's equations. Dependence on pressure and temperature. Gibbs-Helmholtz equation. Free energy changes and equilibrium constant. Chemical potential and fugacity. Thermodynamics of biochemical reactions.

Phase Rule: Terms involved in phase rule and examples, Application of phase rule to one component water system, Application of phase rule to two-component systems. (Simple eutectic systems).

Module II

Quantum Chemistry: Schrodinger wave equation – significance of Ψ, well behaved functions, Postulates of quantum mechanics, Application of quantum mechanics to simple systems - particle in 1 D box, normalization of wave function, Forms of hydrogen atom wave functions and the plots of these functions to explore their spatial variations, Quantum numbers.

Module III

Spectroscopy: Principles of spectroscopy and selection rules. Electronic spectroscopy. Vibrational and rotational spectroscopy of diatomic molecules. Applications. ^{1}H NMR spectroscopy – Principle - Relation between field strength and frequency - chemical shift - spin- spin splitting - coupling constant - applications of NMR- MRI.

Module IV

Electrochemistry: Cell EMF- its measurement and applications. Nernst Equation and application, relation of e.m.f. with thermodynamic functions (ΔH, ΔF and Δ S). Lead storage battery. Corrosion; causes, effects and its prevention.

Polymers- Classifications- Thermoplastics and thermosetting plastics- A brief account of conducting polymers (polypyrrole and polythiophene) and their applications.

Lubricants- Introduction solid and liquid lubricants- Properties of lubricants-Viscosity index- flash and fire point- cloud and pour point- aniline value.
Refractories: Classifications – Properties of refractories.

Laboratory Experiments to be conducted in the virtual lab mode List of Experiments (Minimum six experiments shall be conducted)

1. Determination of the partition coefficient of a solute in two immiscible liquids.
2. Phase diagram of two component System (Naphthalene-diphenylamine)
3. Conductometric titration of **S**trong acids with Strong base.
4. Potentiometric titration: Fe^{2+} vs $KMNO_4$
5. Heat of neutralization
6. Verification of Beer-Lambert's law
7. Determination of rate constant of a reaction.
8. Determination of total hardness of water by EDTA method.
9. Determination of COD of water sample.
10. Determination of alkalinity of water.
11. Determination of chloride content of water by Mohr's method.
12. Determination of dissolved oxygen in a given water sample.
13. Determination of acidity of water sample.
14. Determination of adsorption of acetic acid by charcoal.
15. Determination of acidity of water sample

Text books:

1. B. H. Mahan and R. J. Meyers. University Chemistry, 4th Edition, Pearson publishers. (2009).
2. B.L. Tembe, M.S. Krishnan and Kamaluddin. Engineering Chemistry (NPTEL Web Course).
3. Shashi Chawla. A Textbook of Engineering Chemistry. Dhanpat Rai & Co, New Delhi (2013).

References:

4. Peter W. Atkins, Julio de Paula, and James Keele. Physical Chemistry, 11th Edition, Oxford publishers. (2018).
5. M. J. Sienko and R. A. Plane. Chemistry: Principles and Applications, 3rd Edition, McGraw-Hill Publishers. (1980).
6. C. N. Banwell. Fundamentals of Molecular Spectroscopy, 5th Edition, McGraw-Hill Publishers. (2013).

Pattern of Continuous Assessment

Test – I for the theory portions: 15 marks
Test -II for the theory portions: 15 marks Assignment from the theory portions: 5 marks Laboratory record and Viva -voce: 10 marks (5 + 5) Attendance: 5 marks
The students are required to submit the laboratory record.

23-200-0203B DIGITAL ELECTRONICS

Course Outcomes:

On successful completion of teaching-learning and evaluation activities,a student would able to:

1. Understand the fundamental boolean functions and basic building blocks of Digital systems
2. Design Optimal digital circuits using basic building blocks
3. Analyse Basic digital circuits
4. Understand HDL models of simple circuits

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	3	1									1	3	
CO2	2	2	3										2	2
CO3	1	3	1	2									3	1
CO4	1	1	1	1	3				1			2		3

1-Slightly; 2-Moderately; 3-Substantially

Module I

Digital Concepts and Techniques: Binary arithmetic, Binary coded Decimal, Excess - 3 code, Gray Code. Boolean algebra-Standard Sum of products, Standard Product of sums. Logic gates. Minimization of Boolean function :Karnaugh Map (up to 5 variables) and Quine - McClusky methods. Variable entered mapping. Design of optimal logic function from a given problem statement.

HDL:Basic concepts and modelling of simple circuits

Module II

Combinational circuits: Half adder, Full adder, Subtractor, Ripple Carry adder, Carry look ahead adder, BCD adder, multiplexer, demultiplexer, Basic decoder and encoder circuits,Binary Multiplication.

Sequential circuits: Flip-flops – (RS /JK / MS/T / D)

Serial Adder-Difference between Parallel Adder and Serial Adder

HDL: Models of simple combinational circuits

Module III

Shift Registers: various types - Counters : Asynchronous and synchronous counters, Up-Down counter, Shift Register Counters - Sequence generators

HDL:Models of simple sequential circuits

Module IV

Implementation of logic functions using PLA, PROM. Error Detection and Correction: Parity, (7,4) Hamming code. Practical design considerations: Logic families- Standard logic levels- Current And Voltage Parameters- fan in and fan out-Propagation delay, Noise margin, Speed power product, setup time, hold time.

TTL family NAND gate working principle, Totem pole configuration- Transfer characteristics, Tri-state logic gate.

Note: HDL portion of each module to be evaluated based on assignments ONLY, as part of Continuous Evaluation, subject to a maximum weightage of 50% of marks allocated for assignments

Text book:

1. Kumar, A. Anand. Fundamentals of digital circuits, 4/e PHI Learning, (2016), ISBN- 978-8120352681

References:

1. Floyd, Thomas L. Digital fundamentals, 11/e. Pearson Education India, 2017, ISBN 978- 9332584600
2. Stephan Brown & Zvonko Vranesic, Fundamentals of Digital Logic with Verilog Design, 2/e, McGraw-Hill, (2007) ISBN- 978-0077211646
3. Taub, Herbert, and Donald L. Schilling. Digital integrated electronics. McGraw Hill, India, 2016, ISBN- 978-0070265080
4. Roth Jr, Charles H., Larry L. Kinney, and Eugene B. John. Fundamentals of logic design. Cengage Learning, 2020. ISBN 978-9353502645
5. M. Morris Mano, Michael D. Ciletti, Digital Design: With an Introduction to the Verilog HDL, VHDL, and System Verilog, 6e, (2018), Pearson Education, ISBN: 9789353062019.

23-200-0204B OBJECT ORIENTED PROGRAMMING IN C++

Course Outcomes:

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

1. Understand the basic concepts of Object-Oriented Programming.
2. Describe the object-oriented paradigm with concepts of streams, classes, functions, data and objects.
3. Implement object-oriented programming constructs like encapsulation, inheritance and polymorphism.
4. Understand dynamic memory management techniques using pointers, constructors, destructors, etc.
5. Identify classes including data, methods and the relationship among the classes from a given problem statement and solve the problem using object oriented constructs in C++.

CO POPSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3											1
CO 2	3	2										1
CO 3	3	2	3									2
CO4	3											1
CO5	3	3	3		2	2			2			2

1-Slightly; 2-Moderately; 3-Substantially

Module I

Procedure oriented programming, Object oriented programming paradigm, Basic concepts of object oriented programming, Benefits of OOP, Introduction to C++ programming, data types, variables, control statements (if, if else, switch), iteration (for, while, do...while). Console I/O operations - formatted and unformatted –managing output with manipulators. Functions in C++, call and return by reference, inline functions, default arguments, const arguments.

Module II

Classes and objects, Specifying a class, Defining member functions, Memory allocation for objects Static data members, Static member functions, Arrays of objects, const member functions Constructors and Destructors, Constructors: default, parameterised, with default arguments, copy constructor, destructors,Friend functions.

Introduction to pointers, new and delete operators, Pointers to objects, this pointer.

Module III

Inheritance: Defining derived classes, Single inheritance, Multilevel inheritance, multiple inheritance, Hierarchical inheritance, Hybrid inheritance, Virtual base classes, Abstract classes, Constructors in derived classes .

Polymorphism: Function overloading, operator overloading: overloading unary operators, overloading binary operators, overloading binary operators using friends, manipulation of strings using operators, Type conversions: basic to class, class to basic, class to class.

Module IV

Pointers to derived classes, virtual functions, pure virtual functions.

Working with files: classes for fstream operations, opening and closing of file, detecting end of file, file modes, file pointers and manipulators, sequential input and output operations, random access, Templates, Exception handling.

List of programs to practice:

1. Implementation of classes and objects.
2. Implementation of constructors and constructor overloading.
3. Implementation of methods and method overloading.
4. Implementation of different types of inheritance: Single Inheritance, Multilevel Inheritance, Hierarchical Inheritance, Multiple Inheritance, Hybrid Inheritance.
5. Implementation of polymorphism.
6. Implementation of File handling
7. **Assignment:** Design any real time application using object oriented concepts and develop the solution using the C++programming language. For this the students can form a project team with a maximum 4 members per team.The team can select a socially relevant problem from various domains such as health, safety, education, agriculture, legal etc. At the end of the semester, the team has to demonstrate their product and submit a report. The team will be assessed through rubrics.

Pattern of Continuous Assessment (50 marks)

Test – I for the theory portions: 15 marks
Test -II for the theory portions: 15 marks
Assignment from the Theory: 5 marks
Assignment from the Practice: 10 marks
Attendance: 5 marks
The students are required to submit the practice record.

Text books:

1. Balagurusamy, E. (2020). Object oriented programming with C++ (8th ed.).Tata McGraw Hill. New Delhi
2. Schildt, H. (2012). C++ the complete reference (5th ed.). Osborne McGraw Hill. Berkeley

References:

1. Lafore, R., & Lafore, R. (2002). Object oriented programming in C++ (4/e).Sams Pub.Indianapolis, Indiana.
2. Stroustrup, B. (2013). The C++ programming language (4/e). Reading, Mass.:Addison Wesley.
3. Kamthane, A. (2003). Object oriented programming with ANSI and Turbo C++.Pearson Education.Delhi, India.

23-200-0205B INTRODUCTION TO CYBER PHYSICAL SYSTEMS

Course Outcomes:

On successful completion of teaching-learning and evaluation activities, a student would be able to:

1. Understand the features & components of Cyber Physical Systems
2. Understand the elementary constructs of Arduino Software
3. Develop optimal programs & circuits for interfacing various sensors with Arduino
4. Apply Arduino IDE for developing suitable programs for interfacing sensors & actuators with Arduino & Node MCU

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	2	2									1	3	
CO2	1	2	2										2	2
CO3	1	2	2	2								1	2	3
CO4	1	1	1	1	2							1	2	3

1-Slightly; 2-Moderately; 3-Substantially

Module-I

Introduction to CPS, Key features of CPS-reactive computation, concurrency, Feedback Control of the Physical World, real time computation, safety critical applications, general structure of a CPS, Examples of CPS.

IoT- Characteristics of IoT, Enabling Technologies, Concept of Transducers/sensors-Primary & Secondary, active & passive, analog & digital, Concept about actuators-thermal, electric & mechanical, IoT stack, Levels of IoT.

Module-II

Arduino Basics: Development Boards-Arduino Uno, Node MCU, Arduino IDE, General Program Structure, Basic data types, variables & constants, Operators, control statements, loops, functions, time functions, arrays.

Module-III

Arduino-I/O functions, Arduino PWM, Arduino Communication, LED Interfacing-Sinking & Sourcing methods of LED Connection, LED blinking, fading, Analog read, LED bar graph display, Seven Segment LED Display, interfacing sensors with arduino-humidity, temperature, water detector, PIR, ultrasonic sensor, LDR, Interfacing Push Button Switch-Pull Up & Pull Down Connection.

Module-IV

Arduino for motor control- Control of DC Motor, Servo motor & Stepper Motor.

Introduction to Node MCU/ESP32, Overview of Node MCU and its features, Programming Node MCU via arduino IDE, Interfacing LED, Gas Sensor, Introduction to Wifi Connectivity with Node MCU.

Text books:

1. Rajeev Alur Principles of Cyber-Physical Systems, MIT Press 2015
2. Edward Ashford Lee, Sanjit Arunkumar Seshia Introduction to Embedded Systems-A Cyber-Physical Systems Approach-MIT Press 2017

References

3. Shriram K Vasudevan, Abhishek S Nagarajan, RMD Sundaram, Internet of Things, WILEY 2020
4. Srinivasa K.G, Siddesh G.M, Hanumantha Raju R Internet of Things, CENGAGE 2018
5. Arduino-Tutorials point

23-200-0206B ENVIRONMENTAL AND LIFE SCIENCES

Course Outcomes

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

1. Identify the global environmental issues
2. Examine the types of pollution in society along with their sources
3. Elucidate the basic biological concepts via relevant industrial applications and case studies.
4. Evaluate the principles of design and development, for exploring novel bioengineering projects.

CO PO PSO Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	2	2				3	3						2	
CO2	2	2				2	3						2	
CO3	2	2				2	2						2	2
CO4	2	2				2	2						2	

1-Slightly; 2-Moderately; 3-Substantially

Module -I

Environment, Ecosystems and Biodiversity: Definition, scope and importance of environment — need for public awareness — concept of an ecosystem — structure and function of an ecosystem — producers, consumers and decomposers — energy flow in the ecosystem — ecological succession — food chains, food webs and ecological pyramids — Introduction, types, characteristic features, structure and function of the (a) forest ecosystem (b) grassland ecosystem (c) desert ecosystem (d) aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries) — Introduction to biodiversity definition: genetic, species and ecosystem diversity — biogeographical classification of India — value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values — Biodiversity at global, national and local levels — India as a mega-diversity nation — hot-spots of biodiversity — threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts — endangered and endemic species of India — conservation of biodiversity: In-situ and ex-situ conservation of biodiversity. Field study of common plants, insects, birds; Field study of simple ecosystems — pond, river, hill slopes, etc.

Module -II

Natural Resources: Forest resources: Use and over-exploitation, deforestation, case studies- timber extraction, mining, dams and their effects on forests and tribal people — Water resources:Use and over- utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems — Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies — Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies — Energy resources: Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources. case studies — Land resources: Land as a resource, land degradation, man induced landslides, soil erosion and desertification — role of an individual in conservation of natural resources. The concept of sustainable development.

Environmental Pollution: Definition — causes, effects and control measures of: (a) Air pollution (b) Water pollution and (c) Soil pollution (d) Noise pollution. Management of e-waste.

Module – III

Biomolecules and their Applications (Qualitative): Carbohydrates (cellulose-based water filters, PHA and PLA as bioplastics), Nucleic acids (DNA Vaccine for Rabies and RNA vaccines for Covid19, Forensics – DNA fingerprinting), Proteins (Proteins as food – whey protein and meat analogs, Plant based proteins), Lipids (biodiesel, cleaning agents/detergents), Enzymes (glucose-oxidase in biosensors, lignolytic enzyme in bio-bleaching).

Nature-Bioinspired Materials and Mechanisms (Qualitative): Echolocation (ultrasonography, sonars), Photosynthesis (photovoltaic cells, bionic leaf). Bird flying (GPS and aircrafts), Lotus leaf effect (Super hydrophobic and self-cleaning

surfaces), Plant burrs (Velcro), Shark skin (Friction reducing swimsuits), Kingfisher beak (Bullet train). Human Blood substitutes - hemoglobin-based oxygen carriers (HBOCs) and perfluorocarbons (PFCs).

Module -IV

Human Organ Systems and Bio Designs (Qualitative): Brain as a CPU system (architecture, CNS and Peripheral Nervous System, signal transmission, EEG, Robotic arms for prosthetics. Engineering solutions for Parkinson's disease). Eye as a Camera system (architecture of rod and cone cells, optical corrections, cataract, lens materials, bionic eye). Heart as a pump system (architecture, electrical signalling – ECG monitoring and heart related issues, reasons for blockages of blood vessels, design of stents, pace makers, defibrillators). Lungs as purification systems (architecture, gas exchange mechanisms, spirometry, abnormal lung physiology - COPD, Ventilators, Heart-lung machine). Kidney as a filtration system (architecture, mechanism of filtration, CKD, dialysis systems). Muscular and Skeletal Systems as scaffolds (architecture, mechanisms, bioengineering solutions for muscular dystrophy and osteoporosis).
Bioprinting techniques and materials, 3D printing of ear, bone and skin. 3D printed foods.

Text books:

1. Rajagopalan, R. Environmental Studies: From Crisis to Cure. Oxford University Press, New Delhi, (2015).
2. Erach Bharucha. Textbook of Environmental Studies and Ethics. Universities Press (India), Hyderabad, (2013).

References:

3. Thyagarajan S., Velmurugan N., Rajesh M.P., Nazeer R.A., Thilagaraj W., Barathi S., and Jagannathan M.K. Biology for Engineers, Tata McGraw-Hill, New Delhi, (2012).
4. Arthur T. Johnson. Biology for Engineers, CRC Press, Taylor and Francis, (2019).
5. Sohini Singh and Tanu Allen. Biology for Engineers, Vayu Education of India, New Delhi, (2020).
6. Ibrahim Ozbolat. 3D Bioprinting: Fundamentals, Principles and Applications, Academic Press, (2016).

23-200-0207B DIGITAL ELECTRONICS LAB

Course Outcomes:

On successful completion of teaching-learning and evaluation activities, a student would be able :

1. To understand working of gates, flip flops MUX, DeMUX, Shift registers, counters etc
2. To design digital circuits using appropriate ICs
3. To understand the timing diagrams
4. To develop teamwork skills

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	3	1									1	2	2
CO2	2	2	3										3	2
CO3	1	3	1	2									3	2
CO4	1	1	1	1	3				1			2	1	2

1-Slightly; 2-Moderately; 3-Substantially

Experiments:

Introduction to Data sheet of various digital ICs and their familiarisation to be given before the hands on sessions

1. Half adder and full adder using standard logic gates / NAND gates.
2. Code converters - Binary to Gray and gray to Binary with mode control
3. Binary addition and subtraction (a) 1's complement (b) 2's complement(using7483)
4. BCD adder using7483.
5. Study of MUX, DeMUX & Decoder Circuits and ICs
6. Set up R-S JK & JK Master slave flip flops using NAND/NORGates
7. Asynchronous UP / DOWN counter using JK Flipflops
8. Design and realization of sequence generators.
9. Study of shift registers and Implementation of Johnson and Ring counters using them.
10. Study of counter ICs 7490, 7492, 7493.
11. Study of seven segment display and decoder driver (7447)- virtual lab

Hands-on wiring experiments may be supplemented by simulation using CAD tools / virtual labs etc
At least 8 experiments must be mandatorily completed by every student and recorded.
Students are required to submit a simple project fully conceived, designed and developed by them at the end of the semester

Text books:

1. Herbert Taub, Donald Schilling, *Digital Integrated Electronics,* Tata Mc Graw Hill, 1/e, (2008), ISBN:9780070265080
2.Floyd, Thomas L. Digital fundamentals, 11/e. Pearson Education India, 2017, ISBN 978- 9332584600

23-200-0208B BASIC ELECTRONICS LAB

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able:

1. To design and implement simple hardware circuits using electronic devices and to test the performance and its applications.
2. To study the characteristics of diodes and transistors and implement simple circuits using them.
3. To design simple circuits and mini projects (groups) using sensors and electronic components

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	3	1									1	2	
CO2	1	2	1										2	2
CO3	1	3	1	2					1					3

1-Slightly; 2-Moderately; 3-Substantially

Experiments:

1. Familiarization of electronic components and Electronic instruments – Power Supply, Function Generator, CRO, Multimeter.
2. VI characteristics of PN junction diode.
3. Clipping and clamping circuits
4. Design Rectifying circuits: (with and without filter)
   i. Half Wave Rectifier
   ii. Full Wave Rectifier
5. Characterization of Passive Integrator and Differentiator Circuits.
6. Characterization of Transistor CE Configuration.
7. Design CE Amplifier for a particular Gain.
8. Electronic Systems Hardware Familiarization.
9. Introduction to PCB design.

Text books:

1. Jacob Milman & Christos C Halkias, Integrated Electronics: Analog and Digital Circuits and Systems, 2/e, McGraw Hill Education, (2017).

2.David M. Buchla, Thomas L. Floyd, *Electronics Fundamentals, Circuits, Devices and Applications*, Pearson Education Limited, 8/e (2014) ISBN 978-1-292-02568-1

SEMESTER III

23-200-0301B DIFFERENTIAL EQUATIONS AND COMPLEX VARIABLES

(Common for EEE, EC, CS and IT branches)

Course Outcomes:

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

1. Apply complex analysis principles in engineering scenarios, understanding key concepts like analytic functions, Cauchy's theorem, and contour integration.
2. Employ linear algebra techniques, such as eigenvalues and linear transformations, to solve engineering problems and model real-world systems effectively.
3. Solve partial differential equations using various methods and apply the solutions to analyze phenomena in engineering, machine learning, and computational biology.
4. Utilize advanced differential equations, including wave and heat equations, Alembert's solution, and Fourier series, for modelling and analyzing complex engineering problems.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	3	3	2									2	2
CO 2	3	2	3	2									3	2
CO 3	3	2	3	2									3	2
CO 4	2	3	3	2									2	

1-Slightly; 2-Moderately; 3-Substantially

Module I

Analytic Function: Analytic function, Cauchy-Riemann equation (Cartesian and polar), Harmonic function, Construction of analytic function given real or imaginary parts, Conformal mapping of standard elementary function and bilinear transformation. Applications of Analytic Functions in Signal Processing and Image Analysis.

Module II

Complex Analysis: Cauchy's integral theorem, Cauchy's integral formula and for derivatives, Taylor's and Laurent's expansion (without proof), Singularities, Residues, Cauchy's Residues theorem, Contour integration involving unit circle. Advanced Applications of Complex Analysis in Quantum Mechanics and Electrical Engineering.

Module III

Partial Differential Equations: Formation of partial differential equation eliminating arbitrary constants and function, Solution of the first-order equation, Four standard types, Lagrange's equation, Linear homogeneous partial differential equation with constant coefficient. Applications of Partial Differential Equations in Machine Learning and Computational Biology.

Module IV

Advanced Topics in Differential Equations: One-dimensional wave equation, Alembert's solution and one-dimensional heat flow equation, Solution by the method of separation of variables, Application of Fourier series solution, Solution of Laplace's equation over a rectangular region by the method of separation of variables, Recent Topics: Modern Applications of Wave and Heat Equations in Signal Processing and Materials Science.

The students should be introduced to Computer Algebra Systems (CAS) such as Matlab/Python (utilizing NumPy, SymPy, and SciPy) for both symbolic and numerical calculations. Homework and assignments should be given with the integration of CAS.

Text books:

1. Erwin Kreyszig, Advanced Engineering Mathematics, 11th Edition, John Wiley & Sons, (2022).
2. Grewal, B. S., Higher Engineering Mathematics, 45th Edition, Khanna Publishers, (2023).

References:

3. Churchill, R.V. and Brown, J.W., Complex Variables and Applications, 10th Edition, McGraw Hill, (2021).
4. Stroud, K.A. and Booth, D.J., Advanced Engineering Mathematics, 6th Edition, Palgrave Macmillan, (2019).

Case studies for assignment	
MATLAB	**PYTHON**
1. Study of Complex functions and operations	1. Complex Numbers Arithmetic
2. Differential Equations – Ordinary and Partial	2. Python Complex Numbers as 2D vectors
3. Solving Ordinary Differential Equations	3. Solving first-order linear differential equations
4. Solving system of Ordinary Differential Equations	4. Plotting Characteristic curves
5. Solving Partial Differential Equations	5. Modeling Infectious disease

23-203 -0302 NETWORK THEORY

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to:

1. Familiarize with the various signals, theorems and techniques associated with analysis of networks
2. Apply Laplace transforms to find out the steady state response and frequency response of linear circuits and systems.
3. Perform network characterization using various network parameters.
4. Classify and design different filters.
5. Synthesize different passive networks.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	3	3	3	3		1	1				1	3	2
CO 2	2	3	3	3	2	1			1			1	3	
CO 3	3	3	2	2	1					1		2	3	
CO 4	3	3	3	3	3	2	2	2	2	2	1	1	3	3
CO 5	3	3	3	3	3	2	2	2	2	2	1	1	3	3

1-Slightly; 2-Moderately; 3-Substantially

Module I

Basic Circuit concepts: Circuit elements, Energy sources, Kirchhoff's Laws, Circuit Analysis - Source Transformation, Star-Delta Transformation, Mesh analysis, Nodal analysis; Network Theorems- Superposition, Thevenin's, Norton's, Reciprocity, Maximum Power Transfer; Single Phase AC circuits – Sine Wave, R-L, R-C R-L-C circuits, Steady State AC analysis – Mesh, Nodal, Theorems, Resonance- Series and Parallel, Q Factor, Bandwidth, Magnification.

Module II

Transient Analysis: Initial conditions, DC response of RL, RC and RLC circuits, Rise and decay of current, Time constant. Laplace Transforms and its applications – Laplace transform of important Network functions, The transformed circuit in the S domain, Circuit Analysis using Laplace Transforms– RC, RL and RLC circuits with impulse, step, exponential, pulse and sinusoidal inputs. Network Functions: Driving Point Functions and Transfer function; S domain analysis - complex frequency, Significance of poles and zeros, Necessary conditions for poles and zeros, Time domain response from pole zero plot.

Module III

Two Port Networks: Characterization of two port networks using different parameters – Z, Y, Hybrid and Transmission parameters; Conditions for reciprocity and symmetry, Interrelation between parameters, Interconnections of two port Networks – Cascade, Series and Parallel, T π and Lattice representation of two port Networks, Terminated Two Port Networks. Filters: T and π network, Classification of Filters, Characteristic Impedance, Design of Constant K - Low Pass, High Pass, Band Pass & Band Reject Filters, Design of m derived Low Pass and High Pass filters. Attenuators – Symmetrical and Asymmetrical, Equalizers – Two terminal and Four terminal.

Module IV

Network Synthesis: Hurwitz Polynomials, Properties of Hurwitz Polynomials, Routh-Hurwitz stability criterion, Positive Real Functions, Basic Philosophy of synthesis- removal of a pole at infinity, removal of a pole at origin, removal of conjugate imaginary poles, removal of a constant, Realization of LC, RC and RL Functions – Foster Form and Cauer Form.

Text books:

1. Sudhakar and Shyam Mohan. S. Palli, *Circuits and Networks: Analysis and Synthesis*, Tata McGraw Hill, 4/e, (2010), ISBN 978-9339219604
2. Matthew N O Sadiku, Sarhan M.Musa and Charles K Alexander, *Applied Circuit Analysis*, McGraw-Hill India, 1/e, (2014), ISBN:978-9339204440.
3. VanValken Berg, *Network Analysis*, PHI, 3/e, (2010), ISBN 9780070700215

References:

1. W H Hayt, J E Kemmerly & S M Durbin, *Engineering Circuit Analysis*, Tata McGraw- Hill, 7/e, (2010), ISBN 978-1259098635
2. Ravish.R.Singh, *Electrical Networks*, Tata McGraw Hill, (2017), ISBN 978-0070260962
3. A Anand Kumar, *Network Analysis and Synthesis*, PHI, 1/e, (2019), ISBN 978-9388028103
4. Smarajit Ghosh, *Network Theory: Analysis and Synthesis*, PHI, 6/e, (2010), ISBN 978-9332511040

23-203 -0303 ELECTRONIC CIRCUITS

Course objective:

To analyse the different circuits and design circuits using discrete electronic components.

Course outcomes:

On successful completion of teaching learning and evaluation activities, a student would be able to:

1. Design and analyze basic RC circuits like filters, differentiators and integrators.
2. Plot characteristics of BJT & FET and analyze small signal operation of transistor amplifiers using h-parameters & hybrid-pi models.
3. Analyze feedback amplifiers to determine gain, bandwidth, stability & frequency response and design compensated opamps using pole-zero cancellation & dominant pole techniques.
4. Identify bandwidth enhancement techniques and analyze performance of wideband amplifiers.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	3	3									3	3	1
CO 2	3	3	2									1	2	
CO 3	3	3	3									3	2	2
CO 4	3	3	2	3								2	2	

1-Slightly; 2-Moderately; 3-Substantially

Module I

RC Circuits: passive filters-high pass and low pass, differentiators, integrators. Diodes and their applications: review of Rectifiers, Filters- C, LC and pi.

Switching characteristics of a BJT - BJT switches with inductive and capacitive loads - Non saturating switches.

Review of multivibrators, monostable multivibrators using BJT - Voltage time base generators – simple, bootstrap & Miller configurations, current time base generators.

BJT large signal (Power) Amplifier: Circuits and operations of class-A, Class-B, Class- AB and Class-C amplifiers, Push–Pull amplifiers

Module II

Transistor amplifier small signal analysis: Bipolar Junction Transistors: AC Load line, Stability factor, and thermal stability. Transistors at low frequencies: General analysis of an amplifier using h parameters, analysis of CE, Gain, input and output impedances. Transistors at high frequencies: Hybrid Π model, Amplifier response at high frequencies. Field Effect Transistors: FET & MOSFET biasing and small signal low frequency analysis of CD, CS and CG configurations.

Module III

Feedback amplifiers: Negative Feedback amplifiers - The four basic feedback topologies-voltage series, current series, voltage shunt and current shunt. Analysis and design of discrete circuits in each feedback topology - Voltage, Current, Transconductance and Transresistance amplifiers, its loop gain, input and output impedance, Stability of feedback circuits. Effect of feedback on amplifier poles, frequency compensation-Dominant pole and Pole-zero.

Positive feedback amplifiers: Review of oscillators – RC phase shift and Wein bridge oscillators.

Module IV

Wide band amplifiers - Wide banding techniques – CC–CE /CD-CS cascade, cascode amplifier, Wide banding using inductors.

Differential Amplifiers - BJT differential pair, large signal and small signal analysis of differential amplifiers, Input resistance, Darlington pair, voltage gain, CMRR, non-ideal characteristics of differential amplifier. Frequency response of differential amplifiers, Active load, cascode load, current mirror circuits, Wilson current mirror circuits. MOS differential amplifiers.

Assignments are to be open book problem solving based on reference text books.

Text books:

1. Millman & Halkias, *Integrated Electronics*, McGraw Hill, 2/e, (2017), ISBN 978-0070151420
2. Sedra A S and K C Smith, *Microelectronic Circuits*, Oxford University press, 6/e, (2013), ISBN 978-0195323030

References:

1. David A Bell, *Electronic Devices and Circuits*, Oxford Higher Education, 5/e, (2008), ISBN 0195693409
2. Mohammed S Ghausi, *Electronic Devices and Circuits: Discrete and Integrated* ,Saunders College Publishing, (1995), ISBN 978-0030624810
3. Neamen D, *Electronic Circuits Analysis and Design*, TMH, 3/e, (2007), ISBN 978-0070634336
4. Jacob Milman &Taub, *Pulse Digital & Switching waveforms*, Tata McGraw Hill, 3/e, (2011), ISBN 97800710727247

23-203 -0304 DIGITAL SYSTEM DESIGN

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to

1. Understand standard combinational and sequential modules
2. Design and implement standard sequential systems.
3. Understand timing issues in the design of digital networks.
4. Analyze functions of standard sequential components like registers, counters.
5. Design sequential systems using shift registers and parallel counters.

CO PO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	3		3								3	3	
CO 2	3	3	3	3								2	2	3
CO 3	3	3	2	3								3	3	2
CO 4	3	3	2	3								2	3	
CO5	3	3	3	3								2	2	2

1-Slightly; 2-Moderately; 3-Substantially

Module I

Standard Combinational Modules: Binary Decoders – decoder networks, Binary Encoders, Priority Encoders, Multiplexers – multiplexer trees, Demultiplexers, Shifters – barrel shifter.

Synchronous sequential systems- Mealy and Moore Machines, representation of the state transition and output functions, time behaviour of finite state machines, finite memory sequential systems, equivalent sequential systems and minimization of the number of states

Module II

Sequential Systems:

Binary specification of sequential systems- Different types of sequential systems - pattern recognizer – block pattern recognizer- sequential decoders.

Canonical form of Sequential Networks- Analysis of canonical sequential networks, Design of canonical sequential networks, Flip flop modules, Conversion of flip flops, Analysis of network with flip flops, Design of networks with flip flops.

Module III

Standard Sequential Modules:

Shift registers, Counters, Multimodule implementation of sequential systems – Networks of shift registers - parallel counters. Design of sequential systems with standard sequential modules.

Module IV

Timing characteristics of sequential networks – setup time – hold time – propagation delay – maximum clock frequency. Timing issues in VLSI system design: timing classification- synchronous timing basics – skew and jitter- latch based clocking

Text book:

1. Jan M. Rabaey, A. Chandrakasan, B. Nikolic, *Digital Integrated Circuits- A Design perspective*, Pearson education, 2/e, (2016), ISBN 978-9332573925.

References:

2.Milos Ercegovac, Tomas Lang, Jaime H. Moreno, *Introduction to Digital Systems*, John Wiley & Sons, (2009), ISBN 978-8126522514.

3.John F Wakerly, *Digital Design: Principles & Practices*, Pearson Education, 4/e, (2008), ISBN 978-9332508125.

4.John M.Yarbough, *Digital Logic Applications and Design*, Thomson Learning, (2006), ISBN 978-8131500583.

23-203-0305 MICROPROCESSORS AND MICROCONTROLLERS

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to:

1. Understand the architecture of microprocessor/ microcontrollers and their instruction set
2. Develop efficient programs in Assembly Level language for microprocessor/ microcontrollers
3. Design microprocessor / microcontroller based system with necessary memory interface

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3		3	1	3							3	2	
CO 2	3	3	3	3	3							3	3	3
CO 3	3	3	3	3	3							3	2	2

1-Slightly; 2-Moderately; 3-Substantially

Module I

Introduction to microprocessors: Internal architecture of Intel 8086 microprocessor: Block diagram, Registers, Internal Bus Organization, Functional details of pins, Control signals, External Address / Data bus multiplexing, De- multiplexing, Memory Address space and data organization, Memory segmentation and segment registers, IO Address space. Basic 8086/8088 configuration, Minimum mode and maximum mode. Architecture of a recent Intel microprocessor (at least one)

Module II

Instruction set and Assembly Language Programming of 8086: Instruction set, Instruction Classifications addressing modes, Assembler Directives, Strings, Procedures and Macros. Simple Assembly Language Program examples.

Module III

Interfacing concepts and devices:

Memory chips interface to 8086 with examples

Programmable interfacing devices: - Programmable peripheral interface (Intel 8255), Programmable timer interface (Intel 8253/ 54) -Block diagram and modes of operation. Hardware and Software aspects of Interfacing these peripherals to 8086. Introduction to numeric coprocessor 8087 and its interface to 8086.

Module IV

Overview of the 8051 family. 8051 architecture- memory organization, registers and I/O ports. Addressing modes, instruction sets, and assembly language programming. Programming timer/counter. Interrupts- handling and programming. 8051 interfacing - stepper motor, ADC, DAC, LED and LCD module interface. Introduction to C programming in 8051.

Text books:

1. Lyla B.Das, *The x86 Microprocessors: Architecture,programming and Interfacing (8086 to Pentium, Multicore, atoms, 8051 microcontroller*), Pearson Education, 2/e (2014), ISBN: 9789332536821.
2. Douglas V.Hall and S.S.S.P.Rao, *Microprocessors and its Interfacing,* Mc Graw Hill, 3/e,(2017), ISBN 9781259006159.

References:

3. Barry B.Brey, *The Intel Microprocessors: 8086/8088, 80186/80188, 80286, 80386, 80486, Pentium, Pentium Pro Processor, Pentium II, Pentium III, Pentium 4, and Core2 with 64 -bit Extensions*, Pearson/ Prentice Hall, 8/e, (2009), ISBN 9780135026458.
4. Walter A.Triebel, Walter Triebel, Avtar Singh*, The 8088 and 8086 Microprocessors Programming, Interfacing, Hardware*, Pearson Higher Education & Professional Group, (2014), ISBN 9781292040608.
5. Kishor M.Bhurchandi and Ajoy K.Ray, *Advanced Microprocessors & Peripherals*, McGraw Hill Education (India) Private Limited ,3/e, (2017), ISBN 9781259006135.
6. Muhammad Ali Mazidi, Mazidi, *8051 Microcontroller and Embedded systems*, Pearson Education, (2007), ISBN 9788131710265
7. Subrata Ghoshal, *8051 Microcontroller internals, instructions, programming and Interface*, Pearson, (2010), ISBN 9788131731437.

23-203-0306 SOLID STATE DEVICES

Course objective:
To predict the working of a semiconductor device whose doping and construction details are known and to suggest the doping and constructional details for device catering a particular application. Numerically estimate the performance of a semiconductor device.

Course outcome:
On successful completion of teaching –learning and evaluation activities, a student would be able to:
1. Understand basic concepts of semiconductor physics
2. Understand the theory of junctions and the working of various diodes
3. Analyse the working of JFET and MOSFET
4. Understand the theory of BJT and apply it to different applications

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	2	1	1		1	1			1		2	3	
CO 2	3	2	1	2		1	1			1	1	2	3	
CO 3	3	2	1	2		1	1			1	1	2	3	2
CO 4	3	2	2	2		1	1			1	1	2	2	2

Assignments are to be open book problem solving based on reference text books

Module I
CARRIER CONCENTRATIONS: Electrons and holes, Formation of Energy band, Effective mass, E-K diagram, The Fermi level, Carrier concentration at equilibrium, Direct and Indirect recombination of electrons and holes, Hall effect, Steady-state carrier generation, Quasi-Fermi levels
TRANSPORT PHENOMENA: Drift and Diffusion of Carriers, Semiconductor in Equilibrium, Einstein Equation, Excess carrier generation and Recombination, carrier lifetime, Continuity and Diffusion equations, Haynes-Shockley experiment

Module II
P-N JUNCTIONS:
Unbiased junction: Space Charge at a junction, Steady state condition, The Contact Potential, Depletion Region
Biased junction: Current at a junction, Carrier injection, Diode equation, reverse saturation current, diode characteristics, dynamic resistance, Junction breakdown phenomena, Time variation of stored charge, Reverse recovery transient, junction diode switching characteristics, P-N junction Capacitances
OTHER JUNCTION DIODES: Metal-Semiconductor Junction, hetero junctions, Varactor Diodes, PIN diodes, Tunnel Diode, Current and Voltage in an illuminated junction, Photo Diode, Photo detector, Solar Cells, Light Emitting Diode

Module III
Bipolar Junction Transistor (BJT): Structure and basic operation, Charge transport and current in a BJT, Terminal currents, generalised biasing, Ebers-Moll Model, BJT switching: Turn-on and Turn-off transients, Base narrowing, BJT configurations, input and output characteristics of CE and CB.

Module IV
FET, MOSFET: Construction and Operation of FET, I-V Characteristics of FET, Pinch-off and Transconductance.
MESFET, MOSFET, Band bending, Effect of bias voltage, Threshold voltage, accumulation, Depletion, Inversion, MOS Capacitor, CV characteristics, effects of real surfaces, work function difference, interface charge, Threshold voltage in MOSFET, I-V Characteristics of MOSFET

Text books:

1. Ben. G. Streetman, *Solid State Electronic Devices*, PHI, 5/e, (2005), ISBN 9788120318403
2. Donald Neamen, *Semiconductor Physics and Devices*, TMH, 4/e, (2017), ISBN 978-0071070102

References:

1. S. M. Sze, *Physics of Semiconductor Devices*, Wiley India, 3/e, (2009), ISBN 8126517026
2. Jasprit Singh, *Semiconductor Devices*, Wiley India, 1/e, (2007), ISBN 8126511028
3. Betty Lise Anderson, Richard Anderson, *Fundamentals of Semiconductor Devices,* Mc Graw Hill, 2/e (2018), ISBN 978– 0–07–352956–1

23-203-0307 ELECTRONIC CIRCUITS LABORATORY

Course outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to:

1. Design different amplifiers and oscillator circuits.
2. Develop different multivibrators, switch & amp; sweep circuits and triggering circuits catering to different needs.
3. Understand simulation of electronic circuits using SPICE/Proteus.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	**3**	**3**	**3**	**1**					**3**			**3**	**3**	**1**
CO 2	**3**	**3**	**3**	**3**					**3**			**3**	**3**	**1**
CO 3	**3**	**3**	**3**	**3**	**3**				**3**			**3**		**3**

List of Experiments:

1. Frequency responses of RC Low pass and high pass filters.
2. Zener Regulator- shunt and series
3. Study of feedback amplifier- CE amplifier - gain and bandwidth –with and without emitter bypass capacitor.
4. Characteristics of JFET and amplifier design for a particular gain
5. Oscillators - RC phase shift. Wein Bridge
6. Multivibrators - Astable, Bistable, Monostable
7. Switch& Sweep circuits - Simple transistor sweep, bootstrap sweep
8. Schmitt trigger
9. Power amplifiers.
10. Simulation of experiments listed above using SPICE/proteus

(It is desirable to carry out the implementation followed by simulation)

Text books:

1. Jacob Millman, Christos C Halkais, Satyabrata Jit, *Electronic Devices Circuits*, McGraw Hill, 3/e, (2010), ISBN 9780070700215
2. Sedra A S and K C Smith, *Microelectronic Circuits*, Oxford University press, 6/e, (2009), ISBN 978-0195323030

23-203 -0308 DIGITAL SYSTEMS & PROGRAMMING LABORATORY

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able

1. To analyse the digital circuits in programming and simulation platforms
2. To develop assembly-level programming using assembler tools
3. To interface peripheral to microprocessor
4. To develop teamwork skills

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	**3**	**3**	**3**									**3**	**2**	**3**
CO 2	**3**	**3**	**3**	**3**	**3**							**3**	**2**	**3**
CO 3	**3**	**3**	**3**	**3**								**3**	**2**	**1**
CO 4	**3**	**3**	**3**						**3**			**3**	**1**	**1**

1-Slightly; 2-Moderately; 3-Substantially

List of Experiments:

1. Block level system design in Simulink® / LabVIEW environment/ Proteus etc.
2. Programming using HDL- Basic examples
3. Assembly language program development using Macro assembler and its debugging - Typical programming examples (at least 10 no.s)
4. Interface Devices like stepper motor, ADC and DAC to microprocessor

Text books:

1. Lyla B.Das, *The x86 Microprocessors: Architecture, programming and Interfacing (8086 to Pentium, Multicore, atoms, 8051 microcontroller*), Pearson Education, 2/e (2014), ISBN: 9789332536821.
2. Agam Kumar Tyagi, *MATLAB and Simulink for enginee*rs, Oxford University Press, (2012), ISBN: 9780198072447.
3. Nazeih M. Botros, HDL *Programming Fundamentals: VHDL and Verilog*, Cengage Learning, (2005), ISBN: 9781584508557.
4. Morris Mano and Micheal Ciletti, *Digital Design: With an Introduction to the Verilog HDL, VHDL, and System Verilog*, 6/e (2018), Pearson ISBN 978-9353062019.

23-203 -0309 INTERNSHIP-I

Course Outcomes:
On completion of this course the student will be able to:

1. Understand the real time technical/managerial skills required and relevant to the subject area of internship.
2. Initiate a habit of proper daily diary writing with adequacy and quality of information recorded, drawing and sketches and data, thought process and the proper organization of the information gained during the internship.
3. Conceive the pros and cons of working in a real time industrial incubation/ innovation /entrepreneurship/lab environment and the wonderful results which could evolve through team-work.
4. Present and defend self-prepared and corrected internship reports (with the help of internship guide/industry mentors) of a self-created work to a peer audience.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	**1**					**1**	**2**	**3**		**2**		**3**	**1**	**1**
CO 2		**1**	**1**			**3**	**1**	**3**	**2**	**3**		**3**	**1**	**1**
CO 3	**2**	**2**	**1**		**3**	**1**	**2**	**3**	**1**	**1**	**2**	**2**	**2**	
CO 4						**2**			**3**	**2**	**2**	**1**	**2**	

1-Slightly; 2-Moderately; 3-Substantially

Internship Guidelines

During the summer vacations, after the 2nd Semester, students are required to be involved in Inter/ Intra Institutional Activities viz; Training with higher Institutions; Soft skill training organized by Training and Placement Cell of the University; contribution at incubation/ innovation /entrepreneurship cell of the University; participation in conferences/ workshops/ competitions etc.; Learning at Departmental Lab/ Tinkering Lab/ Institutional workshop; Working for consultancy/ research project within the institutes and Participation in all the activities of Institute's Innovation Council for eg: IPR workshop/Leadership Talks/ Idea/ Design/ Innovation/ Business Completion/ Technical Expos etc.

A committee consisting of the Internship Coordinator (nominated by the Head of the Department/Division), faculty mentor, and at least one senior faculty member at the level of Associate Professor or above will carry out the final review. Training Certificate from the Inter/ Intra Institutional Activities from the concerned department/lab as mentioned above for the prescribed period shall be submitted at the end of the internship which can be considered as evidence for the Internship-1.

Guidelines for evaluation:

Regularity and progress of work	10
Work knowledge and Involvement	10
Semester End presentation and oral examination	10
Level of completion of internship	10
Internship Report – Presentation style and content	10
Total	50 Marks

SEMESTER IV

23-200-0401B NUMERICAL AND STATISTICAL TECHNIQUES

(Common for EEE, EC, CS and IT branches)

Course Outcomes:

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

1. Comprehend foundational concepts in numerical analysis, statistical methods, and machine learning, including understanding the importance of numerical methods and statistical techniques in problem-solving.
2. Apply various numerical methods and statistical tests to solve algebraic and transcendental equations, analyze data, and draw inferences about populations and samples.
3. Evaluate and compare the efficiency of numerical techniques in solving engineering problems, demonstrating analytical skills in differentiation, integration, and solving ordinary differential equations.
4. Apply advanced statistical and machine learning techniques using Pandas for data exploration and processing, showcasing proficiency in descriptive statistics, regression analysis, and the implementation of basic machine learning models.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	3	2	3		1					2		3	
CO 2	3	2	2	2		1					2		2	2
CO 3	3	3	2	2		1					2		2	2
CO 4	3	2	2	3		1					2		2	3

Module I

Fundamentals of Numerical Analysis: Understanding Numerical Methods, Importance in Problem Solving, Error Analysis and Approximations. Numerical solution of algebraic and transcendental equations: Bisection, Newton-Raphson, Secant and Successive Iteration Method. System of Equations: Gauss-Seidel Iteration (Convergence without proof). Interpolation and Approximation: Polynomial, Lagrange, Newton's Forward/Backward/Divided-Difference, and Least Squares. Taylor's Theorem: Taylor series expansion, Taylor Polynomial and Maclaurin Series.

Module II

Numerical Differentiation at Tabulated Points: Forward, Backward, Central Differences. Numerical Integration: Trapezoidal, Simpson's, Gaussian Quadrature. Ordinary Differential Equations (ODEs): Initial Value Problems- Euler's Method, Runge-Kutta (2nd & 4th Order), Boundary Value Problems-Finite Difference Method (First & Second Order BVPs).

Module III

Statistical Concepts and Tests: Random Variables, Expectation, Mean, Variance. Probability Distributions: Binomial, Poisson, Normal. Statistical Inference: Population, Sample, Sampling Distributions (Mean & Variance). Hypothesis Testing: Level of Significance, Z-Test, Chi-Square Tests (Variance & Goodness of Fit), F-Test.

Module IV

Descriptive Statistics and Regression Analysis. Overview of Descriptive Statistics. Regression Analysis of Numerical Data. Regression Analysis of Categorical Data. Visualization of Data Trends. Basic Concepts of Machine Learning: Introduction to Supervised Learning, Overview of Classification and Regression, Introduction to Unsupervised Learning: Clustering. Utilize Pandas for data exploration and processing.

The students should be introduced to Computer Algebra Systems (CAS) such as Matlab/Python (utilizing NumPy, SymPy, and SciPy) for both symbolic and numerical calculations. Homework and assignments should be given with the integration of CAS.

Text books:

1. Erwin Kreyszig, Advanced Engineering Mathematics, 11th Edition, John Wiley & Sons, (2022).
2. Grewal, B. S., Higher Engineering Mathematics, 45th Edition, Khanna Publishers, (2023).

References:

3. R.K. Jain, S.R.K. Iyengar, R.K. Jain, Numerical Methods for Scientific and Engineering Computation, 7th Edition, New Age International Publishers, (2022).
4. Jay L. Devore, Probability and Statistics for Engineering and the Sciences, 10th Edition, Cengage Learning, (2023).
5. Wes McKinney, Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython, 3rd Edition, O'Reilly Media, (2022).
6. Andreas C. Muller, Sarah Guido, Introduction to Machine Learning with Python: A Guide for Data Scientists, 2nd Edition, O'Reilly Media, (2021).

Case studies for assignment	
MATLAB	**PYTHON**
1. Determination of roots of a polynomial	1. Finding roots of functions
2. Determination of polynomial using Least-square method	2. Numerical differentiation
3. Finding Taylor and Maclaurin Series Expansion	3. Numerical Integration
4. Solution of differential equation using Euler method	4. Probability distributions
5. Solution of differential equation using 4^{th} order Runge-Kutta method	5. Regression Analysis

23-203-0402 ANALOG INTEGRATED CIRCUITS

Course Objectives:

To analyse and design operational amplifier circuits and its applications

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to:

1. Analyse and design various feedback circuits using opamps and its applications
2. Understand the working of opamp as comparators, multivibrators, oscillators etc.
3. Design various active filter types using opamp
4. Understand the working of specialized ICs using opamp and its applications

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	3	3	2		1	1	1	1	1	1	1	3	2
CO 2	3	3	3	2	2							1	2	
CO 3	3	3	3	2		1	1	1				1	3	1
CO 4	3	3	3	2	1	1	1	1				1	2	1

1-Slightly; 2-Moderately; 3-Substantially

Module I

Introduction to operational amplifiers: - Internal block schematic - Biasing used in IC- Level Shifters- Power amplifier stages. Op-amp parameters - ideal op amp Frequency response, frequency compensation. Slew rate and its effect; Input bias current – offset - drift - compensating networks CMRR, SVRR, finite gain bandwidth and its effect in opamp circuits' performance. Open loop configurations Op amp in closed loop configuration: Different feedback configurations- Voltage series feedback and voltage shunt feedback - concept of virtual ground- linear circuits: Summer- Subtractor, Integrator and differentiator voltage follower - V/I converters, I/V converters and its applications - Differential amplifiers, instrumentation amplifier- Use of offset minimizing resistor (ROM) and its design.

Module II

Op amp applications: Log amplifier- Antilog amplifier- Comparators: zero crossing- using voltage reference- regenerative (Schmitt trigger) comparators, window detector application – OPAMP as comparators - Astable and monostable multivibrators using opamps- Triangular and saw tooth wave generators- RC phase shift and Wien bridge oscillators-Sample and hold circuit-Peak detector circuit, Precision rectifiers.

Module III

Filters: Transfer functions - LPF, HPF, BPF, BRF. Approximation methods - Butter worth - Chebyshev -Active Filters - I order and II order filters, Quality factor-Design – Gyrator, Negative Impedance Converter (circuit only) - Filter using Simulated Inductance - All Pass filters – Switched capacitor filters.

Module IV

Specialized ICs and applications: Voltage regulator IC 723, current limiting, short circuit protection, Thermal protection -555 timers – Functional block diagram- Astable Multivibrator, Monostable Multivibrator - Application as square wave oscillator - 566 VCO chip- Phase locked loop (PLL) - block diagram, Mathematical Derivation of capture range, lock range and pull in time- 565 PLL - PLL applications: Frequency multiplication and division- AM demodulation - FM detection - FSK demodulation, Analog multiplier circuits and applications.

Text books:

1. Gaykwad, *Op-amps and Linear Integrated Circuits*, Pearson Education/ Prentice-Hall India Ltd, 4/e, (2010), ISBN 978-9332549913
2. Sedra & Smith, *Microelectronic circuits,* Oxford University Press, 5/e, (2009), ISBN 0195116631
3. K R Botkar, *Integrated circuits,* Khanna Publishers, 9/e, (2010), ISBN 81-7409-208-0

References

1. Sargio Franko, *Design with operational Amplifiers Analog IC*s, Tata McGraw Hill, 3/e, (2003), ISBN 9780070530447
2. R F Coughlin, *Op amps and Linear Integrated circuits*, Pearson Education/ PHI Ltd, 6/e, (2010), ISBN 978-0130149916
3. Gray, *Analysis and Design of Analog Integrated Circuit,* John Wiley, 4/e, (2008), ISBN 9788126515691
4. D A Bell, *Opamps and Linear Integrated Circuits,* Prentice-Hall India, 3/e, (2011), ISBN 978-0195696134
5. Jacob Millman & Arvin, *Micro Electronics,* McGraw Hill (1999), ISBN: 9780074637364
6. Razavi, *Fundamentals of Microelectronics,* Wiley India, (2009), ISBN: 9788126523078

23-203 -0403 SIGNALS & SYSTEMS

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to

1. Understand the concept of a signals and systems, their characteristics, classification and analysis using differential /difference equations
2. Understand the concept of impulse response and perform convolution
3. Predict and analyze the response of LTI systems to various types of input signals
4. Understand Sampling theorem and the need for sampling and reconstruction
5. Analyze LTI systems using Laplace transforms /Z transform
6. Understand and evaluate the frequency response of LTI systems using Fourier series and transform

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	1	1				1	1				1	2	
CO 2	3	2	1									1	2	
CO 3	2	2	1		1	1		1	1	1		1	2	2
CO 4	3	1	1			1						1	3	
CO 5	2	1	1		1	1		1	1	1	1	1	2	2
CO 6	2	1	1		1			1		1		1	2	2

1-Slightly; 2-Moderately; 3-Substantially

Module I

Continuous time (CT) and Discrete time (DT) Signals - Introduction - exponential and sinusoidal - unit step and impulse functions / sequences – Classification of signals - CT and DT Systems - Properties of systems - Linear time-invariant (LTI) systems –Basic operations on signals - The representation of signals in terms of impulses - convolution - Properties of LTI systems - differential / difference equation representation - calculation of impulse response.

Module II

Fourier Series and Transforms – Fourier series representation of Continuous time periodic signals - Convergence of Fourier series – Properties - Continuous- time Fourier transform representation of Aperiodic signals – Properties - Fourier transform pairs - Duality

Module III

Laplace transform - The region of convergence for Laplace transforms - The inverse Laplace transform - Properties of the Laplace transform - Analysis and characterization of First-order and second-order LTI systems using the Laplace transform. Sampling – Introduction - Representation of a continuous-time signal by its samples - the sampling theorem –The effect of undersampling: aliasing - Sampling with a zero-order hold

Module IV

Discrete-time Fourier series - Properties - Discrete-time Fourier transform – Properties. Z-transform- The region of convergence – Pole zero plot - Properties of the z-transform - Inverse z-transform (partial fraction method) - Analysis and characterization of LTI systems using z-transforms.

Text book:

1. Alan V Oppenheim, Alan S Willsky, *Signals and Systems,* Prentice Hall India, 2/e, (2010), ISBN 0-13–814757–4

References:

1. Michael D. Adams, Signals and Systems, University of Victoria, 3/e, (2020), ISBN 978-1-55058-673-2
2. Rodger E. Ziemer, Signals & Systems - Continuous and Discrete, Pearson, 4/e, (2013), ISBN 978-0134964560

23-203 -0404 ELECTROMAGNETIC THEORY

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able

1. To understand the significance of Maxwell's Equations and behaviour of electric and magnetic fields under varying boundary conditions.
2. To apply the acquired knowledge on electrostatics, magnetostatics and time varying fields to electromagnetic wave propagation.
3. To analyze fields and potentials using vector analysis tools.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	2		1		1	1					1	3	
CO 2	3	3	1	2	1		1	1				1	3	
CO 3	3	3	1	2	1		1	1				1	2	2

1-Slightly; 2-Moderately; 3-Substantially

Module 1

Vector Analysis: Vector Algebra, Coordinate Systems and Transformation – Cartesian, Cylindrical and spherical coordinates, Vector Calculus – Differential length, area and volume, Line, surface and volume integrals, Del operator, Gradient of a scalar, Divergence of a vector, Divergence Theorem, Curl of a vector, Stoke's Theorem, Laplacian of a scalar.

Module II

Electrostatics: Electrostatic Fields – Coulomb's Law and field intensity, Electric fields due to continuous charge distributions, Electric flux density, Gauss's Law, Applications of Gauss's Law, Electric Potential, Relationship between E and V, Electric dipole and flux lines, Energy density in Electrostatic fields. **Electric fields in material space**: Properties of materials, Convection and conduction currents, Conductors, Polarization in Dielectrics, Dielectric constant and strength, Linear, Isotropic and Homogeneous Dielectrics, Continuity equation, relaxation time, Boundary conditions- Dielectric-Dielectric, Conductor-Dielectric, Conductor-Free Space.

Electrostatic Boundary value problems: Poisson's and Laplace's Equations, Uniqueness Theorem, Resistance and capacitance [Parallel-plate, coaxial, spherical capacitors].

Module III

Magnetostatics: Magnetostatic Fields- Biot-Savart's Law, Ampere's circuital law, Applications of Ampere's circuital law, Magnetic flux density, Magnetic scalar and vector potentials, Derivation of Biot-Savart's Law and Ampere's Law. **Magnetic forces, Materials and devices**: Forces due to magnetic fields, Magnetic torque and moment, Magnetic dipole, Magnetization in materials, Classification of Magnetic Materials, Magnetic boundary conditions, Inductors and inductances, Magnetic energy, Magnetic circuits, Force on magnetic materials. **Maxwell's Equations:** Faraday's Law, Electromotive Forces, Displacement current, Time-harmonic fields, Maxwell's equations for static fields and time varying fields.

Module IV

Electromagnetic wave propagation : Electromagnetic waves-Wave propagation in lossy dielectrics- Wave equations, propagation constant, intrinsic impedance of the medium, complex permittivity, loss tangent, Plane waves in lossless dielectrics, Plane waves in free space – uniform plane wave, Plane waves in good conductors – skin effect, Wave Polarization, Poynting's Theorem, Reflection of a plane wave at normal incidence – standing waves, Reflection of a plane wave at oblique incidence – parallel and perpendicular polarization, Brewster angle.

Text books:

1. Matthew N.O. Sadiku and S V Kulkarni, *Principles of Electromagnetics*, 6/e, Oxford University press (2017), ISBN 978-0199461851
2. Jordan and Balmain, *Electromagnetic waves and radiating systems*, PHI Ltd, 2/e, (2010), ISBN 978-9332551770

References:

3. W.H.Hayt, J.A.Buck and Jaleel M Akhtar *Engineering Electromagnetics*, Tata McGraw Hill, 8/e, (2014), ISBN 978-9339203276
4. W.H.Hayt, and J.A.Buck, *Problems and solutions in Electromagnetics*, TMH, 7/e, (2011)
5. Kraus and Fleisch, *Electromagnetics with applications*, Tata McGraw Hill, 5/e, (2010), ISBN 978-0070702400
6. Joseph A. Edminister, *Electromagnetics*, Schaum's outline series - Tata McGraw Hill, 2/e, (2010), ISBN 978-0070212343

23-203 -0405 INTRODUCTION TO COMMUNICATION ENGINEERING

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able

1. To understand various continuous-wave modulation and demodulation techniques for communication systems, probability theory, random variables and random processes
2. To study the generation, transmission and reception of different modulated signals, correlation, covariance and power spectral density of stationary random processes
3. To analyze the signal spectrum, bandwidth and power requirements, and effect of noise in different modulation schemes
4. To apply the knowledge to solve the basic problems in communication systems

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	2											2	
CO 2	3	1	1	1									3	
CO 3	3	3	2	2	2							1	3	2
CO 4	3	2	2	2	2							1	2	

1-Slightly; 2-Moderately; 3-Substantially

Module I

Introduction to continuous wave modulation: Elements of communication system, electromagnetic spectrum **-** need for modulation - amplitude modulation: switching modulators, envelope detector, sideband and carrier power. DSB-SC: Ring modulator, coherent detection. Single sideband: time domain representation, spectra, modulation techniques, demodulation.

Module II

Angle modulation: concept of instantaneous frequency- relationship between FM and PM- power and bandwidth – Carson's rule. FM generation –direct, indirect method- narrowband and wideband FM. FM demodulation –slope detection. Comparison of AM and FM. Superheterodyne analog AM/FM receivers- Characteristics of receivers – sensitivity, selectivity, image frequency.

Module III

Probability theory & Random processes: concept of probability: conditional probability and Baye's theorem- random variables-statistical averages-correlation-central limit theorem. Characterization of random process - autocorrelation and power spectral density- transmission of random processes through LTI system.

Module IV

Noise: external, internal- signal-to-noise ratio – noise figure –noise calculations – equivalent noise temperature-noise figure in cascaded networks. White noise, filtered white noise, noise equivalent bandwidth, Narrow band noise.

Effect of noise in Systems; Linear and angle modulation systems, threshold effect and threshold extension, pre-emphasis and de-emphasis filtering.

Text books:

1. Simon Haykin and Michael Moher, *Communication Systems*, John Wiley & Sons, 5/e, (2009), ISBN 978-0471697909.
2. B. P. Lathi and Zhi Ding, *Modern Digital and Analog Communication Systems*, Oxford University Press, 5/e, (2018), ISBN 978-0198073802
3. George Kennedy, *Electronic communication systems*, McGraw Hill,6/e,(2017)

References:

4. Taub & Schilling, *Principles of Communication Systems*, Tata McGraw Hill, 4/e, (2017) ISBN 978-1259029851Wayne Tomasi, *Electronic Communications Systems (Fundamentals through Advanced)*, Pearson Education ,5/e, (2008), ISBN 978-8131719534

23-203 -0406 PYTHON FOR MACHINE LEARNING APPLICATIONS

Course Outcomes:

On completion of the course the students will be able:

1. To understand the basic concepts of the python programming environment.
2. To preprocess and visualize any given data
3. To apply OpenCV package for manipulating images
4. To implement simple machine learning problems

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	3	3	3	3							3	3	
CO 2	3	3	3	3	3							3	3	2
CO 3	3	3	3	3	3							3	1	2
CO 4	3	3	3	3	3							3		3

1-Slightly; 2-Moderately; 3-Substantially

Module I

Introduction to Python, Jupyter Notebook, Colab, Familiarisation of SciPy, Numpy
Basic Syntax and Variables, Datatypes: Int, float, string, bool
Data structures: Lists, tuple, dictionaries, sets
Control Flow: If, for, while; Defining functions
Implementation Examples similar to: Checking Energy signal or power signal, Convolution, Output of LTI systems

Module II

Introduction to libraries: Pandas, matplotlib, seaborn
Data Handling: handling missing values, duplicate data, outliers, inconsistent data,
Data visualization: pie chart, histogram, scatter plot, Box plot
Implementation Examples similar to: Plot heatmap of correlation in IRIS dataset, Employee management system

Module III

Introduction to Opencv
Image I/O functions, resizing, affine transformations (rotation, scaling, translation), plotting histogram, drawing shapes, contour and text on images (*Image processing is not required*)
Implementation Examples similar to: Object detection

Module IV

Introduction to Scikit learn package
Usage of functions for data preprocessing, model selection, supervised machine learning, data splitting
Implementation Examples similar to: Classification, Digit Recognition
Familiarization of advanced packages: Pytorch, Keras, Tensorflow
Defining Tensors

Evaluation Guidelines

1. *Classes must be taken hands on.*
2. *This practical oriented course has continuous assessment for 100 marks based on implementation of the projects using different libraries in python. The weightages for the different components shall be as follows:*
   Implementation of project based on Ist module- 15 marks
   Implementation of project based on 2nd module -15 marks

Implementation of project based on 3rd module-25 marks
Implementation of project based on 4th module -30 marks
Report -10marks
Attendance-5marks

3. *Semester End Examination is not envisaged.*
4. *A student should secure a minimum of 50% marks in continuous assessment for a pass in the course.*

Text books:

1. Eric Matthes, *Python Crash Course, 3rd Edition, A Hands-On, Project-Based Introduction to Programming*, No Starch Press, 3/e, (2023), ISBN 978-1718502703

2. Aurélien Géron, *Hands-on Machine Learning with Scikit-Learn, Keras, and Tensor Flow Concepts, Tools, and Techniques to Build Intelligent Systems*, O'Reilly Media Inc, (2022), ISBN 978-9355421982

References

3. Adrain Rosebrock, *Practical Python and OpenCV-An introductory example driven guide to image processing and computer vision*, pyimagesearch, 3/e, (2021)
4. Andreas C. Muller and Sarah Guido, *Introduction to Machine Learning with Python: A Guide for Data Scientists*, O'Reilly Media Inc, (2016), ISBN 978-1449369415

23-200 -0407 UNIVERSAL HUMAN VALUES

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

1. Recognize needs, basic guidelines, content and process of value education, explore the meaning of happiness and prosperity.
2. Understand human being as the co-existence of two realities, self and body and harmony in the individual level.
3. Verify the possibility of ensuring within the naturally acceptable feelings and express those to the others with an expectation of mutual happiness and mutual prosperity.
4. Identify the harmony in society, nature and existence and ensuring them through the effort to fulfil the human goal.
5. Apply the understanding of ethical human conduct to formulate strategies for ethical life and profession.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1			1			2	2	1	2	2	2	2	3	
CO 2			1			2	3	1	3	1	2	2	2	
CO 3			1			2	2	3	3	3	2	2	2	1
CO 4			1			3	3	3	3	3	3	3	3	
CO 5			2			3	3	3	3	3	3	3	3	

1-Slightly; 2-Moderately; 3-Substantially

Module I: Course Introduction - Need, Basic Guidelines, Content and Process for Value Education.

Purpose and motivation for the course, recapitulation from Universal Human Values-I.

Self-Exploration–what is it? – Its content and process; 'Natural Acceptance' and experiential Validation- as the process for self-exploration.

Continuous Happiness and Prosperity – A look at basic Human Aspirations.

Right understanding, Relationship and Physical Facility – the basic requirements for the fulfilment of aspirations of every human being with their priority.

Understanding Happiness and Prosperity rightly- A critical appraisal of the current Scenario.

Method to fulfil the above human aspirations: understanding and living in harmony at various levels.

Include practice sessions to discuss natural acceptance in human beings as the innate acceptance for living with responsibility (living in relationship, harmony and co-existence) rather than arbitrariness in choice based on liking-disliking.

Module II: Understanding Harmony in the Human Being - Harmony in Myself.

Understanding human beings as a co-existence of the sentient 'I' and the material 'Body'.

Understanding the needs of Self ('I') and 'Body' - happiness and physical facility.

Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer).

Understanding the characteristics and activities of 'I' and harmony in 'I'.

Understanding the harmony of I with the Body: Self-regulation (*Sanyam)* and Health; correct appraisal of Physical needs, the meaning of Prosperity in detail.

Programs to ensure Self-regulation (*Sanyam)* and Health.

Include practice sessions to discuss the role others have played in making material goods available to one self, identifying from own life. Differentiate between prosperity and accumulation. Discuss a program for ensuring health vs dealing with a disease.

Module III: Understanding Harmony in the Family and Society- Harmony in Human-Human Relationship.

Understanding values in a human-human relationship; the meaning of Justice (nine universal values in relationships) and the program for its fulfilment to ensure mutual happiness; Trust and Respect as the foundational values of relationship.

Understanding the meaning of Trust; Difference between intention and competence.

Understanding the meaning of Respect, the difference between respect and differentiation; the other salient values in a relationship.

Understanding the harmony in the society (society being an extension of the family): Resolution, Prosperity, fearlessness (trust) and co-existence as comprehensive Human Goals.

Visualizing a universal harmonious order in society- Undivided Society, Universal Order- from family to world family.

Include practice sessions to reflect on relationships in family, hostel and institute as extended family, real-life examples, teacher-student relationship, goal of education etc. Gratitude as a universal value in relationships. Discuss with scenarios. Elicit examples from students' lives.

Module IV: Understanding Harmony in Nature and Existence – Whole existence as Coexistence.
Understanding the Harmony in Nature.
Interconnectedness and mutual fulfilment among the four orders of nature – recyclability and self-regulation in nature.
Understanding Existence as Co-existence of mutually interacting units in all-pervasive space.
Holistic perception of harmony at all levels of existence.
Include practice sessions to discuss human beings as the cause of imbalance in nature (film "Home" can be used), pollution, depletion of resources and role of technology etc.

Implications of the above Holistic Understanding of Harmony on Professional Ethics: Natural acceptance of human values, Definitiveness of Ethical Human Conduct.
Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order.
Competence in professional ethics: a. Ability to utilize professional competence for augmenting universal human order, b. Ability to identify the scope and characteristics of people-friendly and eco-friendly production systems, c. Ability to identify and develop appropriate technologies and management patterns for the above production systems.
Case studies of typical holistic technologies, management models and production systems.
Strategy for the transition from the present state to Universal Human Order: a. At the level of the individual: as socially and ecologically responsible engineers, technologists and managers, b. At the level of society: as mutually enriching institutions and organizations.
Sum up.
Include practice exercises and case studies to discuss the conduct as an engineer or scientist etc.

Textbook:
1. Human Values and Professional Ethics (3rd revised edition) by R. R. Gaur, R Asthana, G P Bageria, Excel Books, New Delhi, 2022.

Reference Books:
1. Jeevan Vidya: Ek Parichaya, A Nagaraj, Jeevan Vidya Prakashan, Amarkantak, 3rd Edition, (2022).
2. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 5th Edition, (2022).

23-203 -0408 MINI PROJECT

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able

1. To analyze the circuit designing capability and the documentation capability.
2. To understand the process of making an electronic product.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	3	3		3				3			3	3	2
CO 2	3	3	3		3				3			3	1	3

1-Slightly; 2-Moderately; 3-Substantially

Case Study/tutorial: Take a simple electronic product and analyze / study: - Overview of product design from Requirement to Product. The design process - Electronic Design Factors- Computer Aided Design. Product Life Cycle. Various dimensions of Electronic Product Design- Industrial design and Engineering design- Aesthetics and Ergonomics- Inputs, control and display interface. Student should do sample Design Documentation, Engineering Documentation and Test Documentation -Component Specification/ Bill of materials. Enclosure sizing, requirement of enclosure, Noise and thermal management - EMI/EMC, EMI standards and regulations, Grounding, cabling, Shielding, Guarding. Students should study the PCB design criteria and its CAD tools taking some case studies. The above analysis/study shall be focused on functionality, strength, material, manufacture/construction, quality, reliability, aesthetics, ergonomics, safety, maintenance, handling, sustainability, cost etc. whichever are applicable.

Design: The project team shall identify an innovative product, process or technology and proceed with detailed design based on the above study. Each batch comprising of 3 to 5 students shall design, develop and realize a complete electronic product. Basic elements of product design must be considered. Fully software/simulation projects are not allowed. Each student shall submit a project report at the end of the semester. The project report should contain the design and engineering documentation including the Bill of Materials and test results. Product has to be demonstrated for its full design specifications. Innovative design concepts, reliability considerations and aesthetics / ergonomic aspects taken care of in the project shall be given due weight.

Guidelines for evaluation:

CE - Continuous evaluation - Level of completion	20 + 5
SE - End-Semester presentation, Oral Examination, documentation and demonstration	10+5+5+5
Total	50 marks

Reference:

1. Michael Luchs, Scott Swan, Abbie Griffin, Design Thinking, John Wiley & Sons, Inc, 2015.
2. Paul Horowitz and Winfield Hill, The Art of Electronics, 3rd edition, Cambridge, 2015

23-203 -0409 ANALOG INTEGRATED CIRCUIT LABORATORY

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to:

1. Design linear Op-Amp circuits.
2. Design various waveform generators using Op-Amps.
3. Design second order RC filters.
4. Understand the use and working of ICs 555 and 723.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	**3**	**3**	**3**						**3**			**3**	**3**	**2**
CO 2	**3**	**3**	**3**						**3**			**3**	**3**	**2**
CO 3	**3**	**3**	**3**						**3**			**3**	**3**	**2**
CO 4	**3**	**2**	**1**						**1**			**1**	**3**	**2**

1-Slightly; 2-Moderately; 3-Substantially

Experiments:

1. Linear circuits
   Circuits using OP- Amps - Inverting & non inverting amplifiers, Summing Amplifier, Differential Amplifier, Instrumentation Amplifier, Integrators & Differentiators, Measurements of offset voltage and its compensation. Precision rectifiers
2. Circuits using op-amps for waveform generation
   i) Astable, monostable multivibrators.
   ii) Wein bridge oscillator
   iii) Triangular, Saw tooth waveform generators
3. Second order Active RC filters: High pass, Low pass
4. Astable and monostable multi-vibrator circuit using 555
5. Voltage regulator using 723
6. Filters using simulated inductance

(*It is desirable to carry out the implementation followed by simulation*)

Text books :

1. Gaykwad, Op-amps and Linear Integrated Circuits, Pearson Education/ Prentice-Hall India Ltd, 4/e, (2010)
2. Sedra & Smith, Microelectronic circuits, Oxford University Press, 5/e, (2009), ISBN :0195116631

SEMESTER V

23-203 -0501 EMBEDDED SYSTEMS

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to

1. Understand the constituents of an embedded systems
2. Develop specifications for an embedded system
3. Utilize modern hardware/software tools for building prototypes of embedded system
4. Develop embedded systems with specifications and technological choice
5. Understand the basics of embedded operating system and its management

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	1	1									1	3	
CO 2	3	3	3									3	2	
CO 3	3	3	3		3							3	2	3
CO 4	3	3	3									3	2	3
CO 5	3	1	1									1	2	

1-Slightly; 2-Moderately; 3-Substantially

Module I:

Introduction to processors, controllers and Embedded systems:

General purpose processor: Basic architecture, Operation, Programmer's view, Development environment, Application Specific Instruction set Processor, Selecting a processor, General purpose processor design. Standard single purpose processors: Peripherals, Timers, counters, watchdog timer, PWM, UART. Overview of Embedded System: - Embedded System, Categories of Embedded System, Requirements of Embedded Systems, Challenges and Issues in Embedded Software Development, major application areas of embedded system. Typical embedded system (block diagram)

Module II:

Interfacing of peripherals with microcontroller: - keyboard, stepper motor, ADC, DAC, LED and LCD, RTC.

Memory: Write ability and storage Permanence, trade-offs

Types of Memory: ROM, Mask programmed ROM, OTP ROM, EPROM, RAM, DRAM family devices and Flash memory devices

Protocols: Serial Protocols - I2C, CAN, FireWire, SPI; Wireless Protocols –IrDA, Bluetooth, IEEE 802.11

Module III:

Introduction to embedded CPUs: Basic architecture of ARM core family-features of ARM 926EJS core.

Basic architecture of MSP430-features of MSP430. Basic architecture of PIC microcontroller-features of PIC microcontroller.

Module IV

Introduction to embedded firmware and operating systems: Boot loader –Real-time Kernel-Embedded OS- Tasks, Processes and Threads. Processes and Operating systems: Multiple Tasks and multiple Processes, Preemptive Real time OS, Priority based Scheduling, Interprocess Communication, Power management and optimisation for processes. Multiprocessing and Multitasking, Task scheduling, Task communication and synchronization, Device Drivers.

Text books:

1. Wayne Wolf, *Computer as Components Principles of Embedded computing system design*, Morgan Kauffmann, 2/e, (2008), ISBN 978-0123743978
2. K Uma Rao, Andhe Pallavi, *The 8051 and MSP430 Microcontroller Architecture Programming and Applications*, Wiley, (2019), ISBN 978-8126577545
3. Rajkamal, *Microcontrollers - Architecture, programming, Interfacing and system Design*, Pearson Education, 2/e, (2011), ISBN 978-8131759905

References:

4. Frank Vahid, Tony Givargis, *Embedded system Design: A Unified Hardware/software introduction*, Wiley, (2006), ISBN 978-8126508372
5. Shibu K.V*, Introduction to Embedded Systems*, Tata McGraw Hill, 2/e, (2009), ISBN 978-9339219680
6. Daniel W. Lewis, *Fundamentals of Embedded Software where C and Assembly Meet*, Pearson, (2001), ISBN 978-0130615893
7. Steve Heath, *Embedded system design*, EDN Series, 2/e, (2002), ISBN 9780750655460
8. Kantha Rao, *Embedded systems*, PHI, (2011), ISBN:978-81-203-4081-7
9. Subrata Ghoshal, *8051 Microcontroller internals, instructions, programming and Interface*, Pearson, (2010), ISBN 9788131731437
10. Steve Furber, ARM System on Chip Architecture, Pearson, 2/e, (2014), ISBN 978-9332555570
11. Andrew Sloss, Dominic Symes, Chris Wright, *ARM System Developer's Guide: Designing and Optimizing System Software*, Morgan Kauffman, (2004), ISBN 978-1558608740
12. Tammy Noergaard, *Embedded System Architecture, A comprehensive guide for Engineers and Programmers*, Elsevier, (2005), ISBN 978-0750677929

23-203-0502 MICROWAVE ENGINEERING

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to:

1. Analyze transmission line parameters and apply Smith chart for impedance matching and transmission line applications.
2. Formulate the scattering matrix for various microwave hybrid circuits
3. Analyze the operation and applications of various microwave semiconductor devices like IMPATT, TRAPATT, varactor and pin diodes.
4. Understand the limitations of conventional tubes at microwave frequencies and the construction, working of klystrons, TWTAs, magnetrons. Discuss basics of microwave measurements.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	3	3									3	3	2
CO 2	3	1	1									1	2	
CO 3	3	3	3	3								3	2	
CO 4	3	1	1	2								1	2	

1-Slightly; 2-Moderately; 3-Substantially

Module I

Introduction to microwaves - frequency range, significance, applications.

Transmission Line Theory: Lumped element circuit model, Transmission Line equations and Solutions, Reflection Coefficient and Transmission Coefficient, Standing Wave and Standing Wave Ratio, Line impedance and admittance, Smith Chart, Input impedance of a Lossless Line, short circuited and open circuited lines, Impedance matching devices – Quarter wave transformer, Transmission line resonators – $\lambda/2$ and $\lambda/4$ resonators, Stub matching, Smith Chart and its applications.

Module II

Waveguides - Rectangular Waveguide: TE waves, TM waves, Velocities of propagation; dominant and degenerate modes, Impossibility of TEM waves in wave guides; Power Transmission and Power Losses in Rectangular Waveguides, Excitation of modes in Rectangular Waveguides

Rectangular Cavity Resonator: Resonant frequency and Q factor, Cavity excitation and tuning. **Microwave Hybrid Circuits**: E plane Tee, H plane Tee, Hybrid Tee, Hybrid Ring, Two-hole directional coupler, Isolator, Circulator, Phase shifter, Attenuator.

Scattering matrix representation: Properties of S matrix, S matrix formulation of E plane Tee, H plane Tee, Magic Tee, Directional coupler, Circulator

Module III

Solid State Microwave Devices: Diodes – Principle of operation and applications of Crystal diode, Schottky diode, PIN diode, Varactor diode, Tunnel diode, Gunn diode.

Avalanche Transit time devices: IMPATT, TRAPATT

Parametric amplifiers: Basic principle of operation, Manley-Rowe power relations, Negative resistance amplifiers

Module IV

Microwave tubes: High frequency limitations – Structure and Principle of operation of Two Cavity Klystron, Reflex Klystron, Traveling Wave Tube Amplifier, Magnetron Oscillator (detailed mathematical analysis not needed)

Microwave measurements: Measurement of Power, VSWR, frequency, wavelength, insertion loss, impedance and attenuation; Basic concepts of Network Analyzer and Anechoic chamber

Text books:

1. David.M. Pozar, Microwave Engineering, John Wiley, 4/e, 2021, ISBN 9781119543809
2. Samuel Y Liao, Microwave Devices & Circuits, Pearson Education, 3/e, 2018, ISBN-8177583530

References:

3. Edward C. Jordon, Keith G. Balmain, *Electromagnetic waves and Radiating systems*, Pearson, 2/e, 2015, ISBN 978-9332551770
4. Peter A. Rizzi, *Microwave Engineering – Passive circuits,* PHI Ltd ,1/e, 1998, ISBN 978-8120314610.
5. Robert E. Collin, *Foundations for Microwave Engineering,* Wiley India, 2/e, 2007, ISBN 978-8126515288.
6. Annapurna Das and Sisir K Das, *Microwave Engineering*, Tata McGraw Hill, 4/e, 2020, ISBN 978-9390113347.

23-203-0503 DIGITAL COMMUNICATION ENGINEERING

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to:

1. Understand waveform coding techniques, signal space representation of signal using GS orthogonalization procedure, digital modulation and demodulation schemes, line coding, optimal receivers.
2. Analyse baseband signals in time and frequency domain, error performance of modulation schemes, ISI and pulse shaping techniques, equalizers, synchronization techniques.
3. Apply the knowledge of performance of different modulation schemes for the design of communication systems.
4. Design communication systems under given power, spectral and error performance constraints.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	1	1	1								1	3	
CO 2	3	3	3	3								3	3	2
CO 3	3	1	2	2								3	2	
CO 4	3	3	3	2								3	2	1

1-Slightly; 2-Moderately; 3-Substantially

Module I

Pulse Modulation & Waveform Coding Techniques: PAM, PWM, PPM, Multiplexing- TDM, FDM. PCM system- quantization process- uniform and nonuniform quantization, Quantization Noise & SQNR, Robust quantization, companding- A Law and μ Law characteristics. DPCM-transmitter and receiver. Delta Modulation - transmitter and receiver, quantization error. Adaptive delta modulation.

Module II

Introduction to Digital Communication: Model of digital communication system, Gram-Schmidt orthogonalization procedure, Geometric interpretation of signal, Response of bank of correlators to noisy input, Detection of known signals in noise, Probability of error, correlation & matched filter receiver, detection of signals with unknown phase in noise.

Module III

Digital Modulation Techniques: Binary modulation techniques- ASK, PSK, FSK- probability of error under coherent detection. M-ary Modulation techniques: QPSK, QAM (Block level treatment only), Bandwidth efficiency. Non-coherent detection: receiver architecture, DPSK.

Module IV

Baseband data transmission: Line codes-NRZ, RZ; unipolar, polar, bipolar, Manchester. Intersymbol interference - Pulse shape design for channels with ISI: Nyquist pulse, Partial response signalling. Eye Pattern, scrambling and descrambling, Zero forcing Equalizer, Synchronization: Carrier synchronization, symbol synchronization.

Text books:

1. Simon Haykin, *Digital Communications*, Wiley, (2017), ISBN 978-8126508242
2. B. P. Lathi and Zhi Ding, *Modern Digital and Analog Communication Systems*, Oxford University Press, 5/e, (2018) ISBN: 9780190686840

References:

3. John G Proakis & M. Salehi, Digital Communication, 5/e, (2014), McGraw-Hill, ISBN-10. 9789339204792
4. Taub & Schilling, *Principles of Communication Systems*, Tata McGraw Hill, 4/e (2013) ISBN-10. 0070648115
5. Bernard Sklar, *Digital Communications Fundamentals and applications*, Pearson ed., 3/e, (2021) ISBN-13. 978-0134588568
6. Hwei Hsu, Schaum's Outline, *Analog and Digital Communications*, McGraw Hill, 3/e, (2017). ISBN-13: 9780070151505

23-203-0504 VLSI DESIGN

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to:

1. Understand different processing steps in IC fabrication and the various second order MOS device effects
2. Understand the concept of pass transistor switch logic, NMOS and CMOS inverters
3. Apply design rules and layout of static MOS circuits
4. Analyse the performance estimation parameters like resistance, capacitance and time delay and the concept of scaling in MOS circuits

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	3				1	1	1				1	3	
CO 2	3	3				1	1	1				1	2	
CO 3	3	3	1		1	1	1	1				1	2	2
CO 4	3	3	1		1	1	1	1				1	2	2

1-Slightly; 2-Moderately; 3-Substantially

Module I

VLSI process integration: NMOS IC technology - CMOS IC technology- n-well process, p-well process, twin-tub process, silicon on insulator. Second order MOS device effects: short-channel effect, narrow width effect, sub-threshold current, field dependent carrier mobility, device saturation characteristics, drain punch through, hot electron effect.

Module II

Switch logic- pass transistors and transmission gates, Gate logic - The basic inverter using NMOS - pull up to pull down ratio- transfer characteristics- Alternate forms of pull up. CMOS logic – inverter, NAND, NOR, 0 compound gates - CMOS inverter DC characteristics.

Module III

Design rules and Layout of static MOS circuits: general principles & steps of lay-out design - use of stick diagrams – NMOS and CMOS design rules - Layout examples of inverter, NAND and NOR - Interlayer contacts, butting and buried contacts - use of layout tools like MICROWIND for integrated circuits.

Module IV

Circuit characterization and performance estimation: resistance estimation - sheet resistance, capacitance estimation, switching characteristics of CMOS inverter- rise time, fall time, delay time, delay unit, inverter delays - driving large capacitive loads - cascaded inverters, super buffers, BiCMOS drivers. Scaling of MOS circuits: scaling models and scaling factors for device parameters.

Text books:

1. Douglas A Pucknell, Kamran Eshraghian, *Basic VLSI Design*, Prentice Hall India, 3/e,(2010) ISBN : 9788120309869
2. Weste and Eshraghian, *Principles of CMOS VLSI Design-A Systems Perspective*, Pearson Education, 2/e, 2006. ISBN-13: 978-0201082227

References:

3. Wolf, Modern *VLSI Design-System- on -Chip Design*, Pearson Education, 3/e, (2002) ISBN 9788177588217.
4. Thomas E. Dillinger, *VLSI Engineering,* PHI,2019 ISBN-13: 978-0139427312
5. Charles H Roth Jr, *Fundamentals of Logic Design,* Jaico Publishers,5/e, 2020

23-203-0505 DIGITAL SIGNAL PROCESSING

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to

1. Understand the need for DFT and the properties associated with it
2. Apply FFT algorithms (DIT and DIF)
3. Analyse the various forms of FIR and IIR filters
4. Design simple FIR/IIR filters of different types
5. Understand the effects of Finite register length in FIR and IIR filter design
6. Understand different types of DSP processors available and their architecture

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	2	1	1	1				1	1		2	2	
CO 2		2	3	1	1				1	1		2	2	2
CO 3	2	1				1	2	2	2	2	1	1	2	
CO 4	1	1	1	2	1	1	2	2	2	2	1	1	2	2
CO 5	2	1		1		1	1	1	1	1	1	1	2	
CO 6	3		1	1								1	2	

1-Slightly; 2-Moderately; 3-Substantially

Module I

Discrete Time Fourier Transform (DTFT) – Introduction - Discrete Fourier Transform (DFT) – Properties – circular convolution – Linear convolution – Efficient computation of DFT: Fast Fourier Transform (FFT) – Decimation in Time (DIT) – Decimation in Frequency (DIF) – Block convolution.

Module II

Finite Impulse Response (FIR) Filters – Basic structures – direct, cascade, linear phase and lattice - Design of FIR filters – Fourier series truncation – Windowing: Rectangular - Bartlett - Blackman – Hanning / Hamming – Frequency Sampling – Finite register length effects.

Module III

Infinite Impulse Response (IIR) Filters – Basic structures: Direct form I & II, cascade and Parallel – Design of IIR Filters – Butterworth – Chebyshev - Impulse Invariance – Bilinear Transformation – Frequency transformations –Finite register Length effects.

Module IV

General and Special purpose Digital Signal Processors –Harvard architecture – Pipelining – Hardware Multiplier Accumulator -Special Instructions - Fixed and Floating Point Processors – TMS320C54X –Architecture –Instruction set - Addressing modes – TMS320C67X – Architecture - Instruction set Addressing modes.

Text books:

1. Oppenheim, Alan V, and Ronald W. Schaffer., *Discrete Time Signal Processing*, Prentice Hall / Pearson Education, 3/e, (2014). ISBN-13: 9780137549771
2. Emmanuel C. Ifeachor & Barni W. Jerris, *Digital Signal Processing, A practical approach*, Pearson education, 2/e, (2001), ISBN 978-0201596199.

References:

3. Sen M.Kuo, Woon-Seng Gan, *Digital Signal Processors: Architectures, Implementations and Applications*, Pearson Education, (2005) ISBN 10: 0130352144
4. Andreas Antoniou, *Digital Filters Analysis & Design*, Prentice Hall India, (2018), ISBN-13: 978-0071846035
5. Lyons, Richard G., *Understanding Digital Signal Processing*, Prentice Hall, 3/e, (2010), ISBN 978-8131764367

23-203-0506 (IE) FPGA BASED SYSTEM DESIGN USING VERILOG HDL

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to

1. Model circuits with Verilog HDL at behavioral, structural and RTL levels.
2. Develop test benches for the simulation of circuits.
3. Understand necessary Verilog HDL modeling techniques to write models, run simulations and to build small digital circuits
4. Understand advanced verilog concepts of timing simulation, logic synthesis and verification
5. Understand Fault diagnosis, FPGA architecture, reconfigurable computing and hardware software co design.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	3	3		3							3	3	3
CO 2	3	3	3									3	2	2
CO 3	3	3	3									1	2	1
CO 4	3	1	1									1	2	
CO 5	3	1	1									1	2	

1-Slightly; 2-Moderately; 3-Substantially

Module I

Introduction to Verilog HDL: Overview of digital design with Verilog HDL, Hierarchical modelling concepts, Lexical conventions, Modules and ports, Gate level modelling, Dataflow modelling, Behavioral modelling. Examples-multiplexers, counters, FSM Tasks and functions

Module II

Advanced Verilog: Useful modelling techniques, Timing and delays, Logic synthesis with Verilog HDL, Examples of sequential circuit synthesis, Verification techniques

Module III

Fault Diagnosis and Testability Algorithms

Fault classes and Models-Fault diagnosis and Testing-Fault table method-path sensitization method – Boolean difference Method-D algorithm - Tolerance techniques – The compact algorithm – Fault in PLA – Test generation-DFT schemes – Built in self-test

Module IV

FPGA Architecture and basis of Hardware software co design: - FPGA Generic Architecture. FPGA types- FPGA programming technologies: antifuse-static RAM-EPROM-EEPROM. FPGA families: Actel- Actel1 logic module, Xilinx-Xilinx LCAXC3000CLB, Altera-Altera FLEX logic element. Logic expander. Interfacing using FPGA: VGA, Keyboard, LCD. Implementation of Vending machine

Text book:

1. Wayne Wolf, *FPGA Based System Design, Prentices Hall Modern Semiconductor Design Series*, 1st edition, ISBN-13: 978-0137033485

References:

1. Samir Palnitkar, *Verilog HDL: A Guide to Digital Design and Synthesis,* Prentice Hall, 2/e, 2003, ISBN 978-8177589184.
2. Nripendra N Biswas, *Logic Design Theory,* Prentice Hall, (1992), ISBN 978-0135243985
3. Stephen Brown & Zvonko Vranesic, *Fundamentals of Digital Logic with Verilog Design,* TATA McGraw Hill Ltd. 3/e, 2013, ISBN 978-0073380544.
4. Seetharaman Ramachandran, *Digital VLSI System Design: A Design Manual for implementation of Projects on FPGAs and ASICs Using Verilog*, Springer Publication, 2007 edition, ISBN 978-9401782777.
5. Kumar, Nitish, *FPGA-Based System Design and Practice*, 1st edition, Springer, 2022.
6. Thomas, Donald E., and Philip R. Moorby, *The Verilog Hardware Description Language*, 6/e, Springer, 2017, ISBN 978-1402070891.

23-203-0507 POWER ELECTRONICS

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to:

1. Analyze various single phase and three phase power converter circuits.
2. Understand the basic principle of switching circuits.
3. Familiarize the operation principle of AC-DC, DC-DC, DC-AC conversion circuits and their applications.
4. Understand the requirements imposed by electric drives.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	3	3	3	3		1	1				1	2	
CO 2	3	3	1	2	1	1						2	2	
CO 3	3	2			1		1					1	2	
CO 4	3	2	2	1								1	2	

1-Slightly; 2-Moderately; 3-Substantially

Module I

Power Semiconductor devices: Basic structure, I V characteristics, switching characteristics and operation of devices like power diode, Bipolar Junction Transistor, Power MOSFET, thyristors, Gate Turn off thyristor, Insulated Gate Bipolar Transistor and TRIAC, two transistor model of thyristor, series and parallel connections of thyristors, protection of thyristors, snubber circuits, Gate and Base drive, firing circuits with resistor and UJT.

Module II

Power Electronic Circuits: Line frequency single phase and three phase diode rectifiers, performance parameters, controlled rectifiers: single phase, semi converter, full converter (with R and R L loads), three phase half converter and full converter (with R and R L loads). Inverters: single phase half bridge and full bridge inverters, three phase inverters, basic concept of Pulse Width Modulation, single pulse, multiple pulse and sinusoidal pulse, basic concept of resonant pulse inverters.

Module III

DC-DC Converters: Various types of commutation techniques, principle of chopper operation, types of chopper circuits, step down operation and step up operation, analysis of Buck regulator, Boost regulator and Buck-Boost regulator. Power Supply Applications: Switching DC power supply, over view of Switching power supplies, control of SMPS, power supply protection, Power Conditioners, Power Line disturbances and Uninterruptible Power supply (UPS), various block of UPS.

Module IV

Motor Drive Applications: Introduction, types of DC motors, basic characteristics of DC motor, operating modes, Single phase drives: Half converter, semi converter and full converter drives. Types of AC motors, induction motor drives, performance characteristics, various types of control drives: such as stator voltage, rotor voltage and frequency control, criteria for selecting drive components.

Text books:

1. Rashid, Muhammad H, *Power Electronics: Circuits, Devices and Applications*, 5th edition, Pearson, 2020. ISBN: 978-8187972228
2. Hart, Daniel W, *Power Electronics*, 2nd edition, McGraw-Hill Education, 2020. ISBN: 9780073380674.

References:

3. Mohan, Ned, Tore M. Undeland, and William P. Robbins, *Power Electronics: Converters, Applications, and Design*, 4th edition, Wiley, 2020. ISBN-9788126510900
4. Erickson, Robert W. and Dragan Maksimovic. *Fundamentals of Power Electronics*, 3rd edition, Springer, 2020, ISBN 978-0792372707.

23-203-0508 COMPUTER ORGANIZATION AND ARCHITECTURE

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to

1. Study the basic structure and operation of a digital computer system.
2. Analyse design of arithmetic & logic unit and understanding of the fixed point and floating point arithmetic operations.
3. Implement control unit techniques and the concept of Pipelining.
4. Understand the hierarchical memory system, cache memories and virtual memory.
5. Understand the different ways of communicating with I/O devices and standard I/O interfaces

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	1	1									1	3	
CO 2	3	3	3									3	2	
CO 3	3	1	2									3	2	2
CO 4	3	1	1									1	2	
CO 5	3	1	1									3	3	

1-Slightly; 2-Moderately; 3-Substantially

Module I

Introduction: Functional units of digital system and their interconnections, buses, bus architecture, types of buses and bus arbitration. Register, bus and memory transfer. Processor organization, general registers organization, stack organization and addressing modes.

Arithmetic and logic unit: Look ahead carries adders. Multiplication: Signed operand multiplication, Booths algorithm and array multiplier. Division and logic operations. Floating point arithmetic operation, Arithmetic & logic unit design. IEEE Standard for Floating Point Numbers

Module II

Control Unit: Instruction types, formats, instruction cycles and sub cycles (fetch and execute etc), micro operations, execution of a complete instruction. Program Control, Reduced Instruction Set Computer, Pipelining. Hardwire and micro programmed control: micro programme sequencing, concept of horizontal and vertical microprogramming.

Module III

Memory: Basic concept and hierarchy, semiconductor RAM memories, 2D & 2 1/2D memory organization. ROM memories. Cache memories: concept and design issues & performance, address mapping and replacement, Virtual memory: concept implementation.

Module IV

Input / Output: Peripheral devices, I/O interface, I/O ports, Interrupts: interrupt hardware, types of interrupts and exceptions. Modes of Data Transfer: Programmed I/O, interrupt initiated I/O and Direct Memory Access., I/O channels and processors.

Text books:

1. Carl Hamacher, Zvonko Vranesic, Safwat Zaky, *Computer Organization*, McGraw-Hill, Fifth Edition, Reprint ISBN-13: 978-0-07-025883-9
2. Stallings, William. *Computer Organization and Architecture: Designing for Performance*, 11th edition, Pearson, 2020. ISBN-13: 978-0134101613

References:

3. M. Mano, Computer *System Architecture*, Pearson Education, revised 3/e, 2017, ISBN978-9332585607
4. John P. Hayes, *Computer Architecture and Organization*, Tata McGraw Hill, Third Edition ISBN, 0070273553
5. Behrooz Parahami, *Computer Architecture*, Oxford University Press, Eighth Impression, 2013, ISBN-13: 978-0132392273
6. Patterson, David A., and John L. Hennessy. *Computer Organization and Design RISC-V Edition: The Hardware Software Interface*, 2nd edition, Morgan Kaufmann, 2020. ISBN 13: 9780128122754

23-203-0509 OPTICAL FIBER COMMUNICATION

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to:

1. Understand the theoretical background of components and devices used in optical communication
2. Design and implement a simple optical communication system.
3. Analyse the factors that limit the capacity of optical fiber communication

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	1	1									2	3	
CO 2	3	3	3									3	2	
CO 3	3	3	3									3	2	1

1-Slightly; 2-Moderately; 3-Substantially

Module 1

Overview of optical communication systems, History of optical communications, Wave theory of light, Reflection and refraction of plane waves; Optical waveguides Planar waveguides, Characteristics of optical fibers, numerical aperture, Wave propagation in multimode and single-mode optical fibers, Coupling into and out of fibers, attenuation, group-velocity dispersion, optical nonlinearities, polarization-mode dispersion. dispersion shifted and polarization maintaining fiber.

Module II

Optical sources and transmitters: Optical sources, Physics of light emission and amplification in semiconductors, -direct and indirect band gap materials-LED structures- quantum efficiency- modulation. Laser diodes- rate equations- diode structure- single mode laser- modulation- temperature effects- quantum cascade lasers-vertical cavity surface emitting lasers- modal noise- partition noise- reflection noise. Light coupling-source to fiber coupling. Photo detectors-PIN, APD, Photo detector noise - response time- structure of detectors- receiver units.

Module III

Components of fiber optic networks: – couplers - splitters- semiconductor optical amplifiers- Erbium doped fiber amplifiers- wavelength division multiplexers/ demultiplexers. Filters- isolators-circulators-optical switches- Wavelength converters- Fiber gratings tunable sources- tunable filters.

Module IV

Dispersion in optical communication systems, Dispersion in single-mode and multimode fibers, Dispersion-induced pulse broadening in single-mode fiber, coherent & non-coherent detection, channel capacity, various limits of transmission rate- Optical link design, Power and noise budget, Jitter and rise time budgets.

Text books:

1. Keiser, Gerd. *Optical Fiber Communications*, 5th edition, McGraw-Hill Education, 2021.
2. Senior, John M., and M. Yousif Jamro. *Optical Fiber Communications: Principles and Practice*, 4th edition, Pearson Education, 2019. ISBN 978-0130326812

References:

3. Agrawal, Govind P. *Fiber-Optic Communication Systems*, 5th edition, Wiley, 2021. ISBN 1119737362
4. Ramaswami, Rajiv, Kumar Sivarajan, and Galen Sasaki. *Optical Networks: A Practical Perspective*, 4th edition, Morgan Kaufmann, 2019. ISBN 978-0-08-092072-6

23-203-0510 DIGITAL SIGNAL PROCESSING LABORATORY

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to

1. Have an idea about the functions of the Signal processing toolbox in MATLAB
2. use the tool box to analyze simple signals and systems
3. Understand the techniques involved in DSP.
4. gain knowledge about frequency response / spectrum of signals and systems
5. implement FIR and IIR systems using MATLAB/PYTHON

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	**3**	**1**	**1**		**3**							**2**	**2**	**2**
CO 2	**3**	**1**	**2**		**3**							**2**	**3**	**3**
CO 3	**3**	**1**	**1**		**3**							**2**	**2**	**1**
CO 4	**3**	**2**	**2**	**2**	**3**	**1**						**2**	**1**	**2**
CO 5	**3**	**3**	**3**	**3**	**3**							**2**	**2**	**3**

1-Slightly; 2-Moderately; 3-Substantially

Experiments:

1. Discrete time signals and Systems: Discrete-time Signals - Discrete Systems - Convolution – Correlation- Difference Equations
2. The *z*-Transform: The Bilateral *z*-Transform - Important Properties of the *z*-Transform - Inversion of the *z*-Transform - System Representation in the *z*-Domain -Solutions of the Difference Equations
3. The Discrete time Fourier Analysis: The Discrete-time Fourier Transform (DTFT) - The Properties of the DTFT - The Frequency Domain Representation of LTI Systems - Sampling and Reconstruction of Analog Signals
4. DFT – FFT
5. Implementation of Discrete Time Filters: IIR Filter Structures - FIR Filter Structures
6. Filter Design: FIR filters – IIR filters
7. IIR Filtering Experiments: Signal Enhancement and Noise Reduction

The above experiments should be done using MATLAB/PYTHON/OCTAVE

References:

1. Ingle, Vinay K., and John G. Proakis. *Digital Signal Processing Using MATLAB*, 3rd edition, Cengage Learning, 2011. ISBN-10: 1-111-42737-2
2. Allen B. Downey, *Think DSP: Digital Signal Processing using Python*, O'Reilly Media, ISBN:9781491938515, 149193851X, 2016.
3. Stearns, Samuel D. and Don R. Hush. *Digital Signal Processing with Examples in MATLAB*, 2nd edition, CRC Press, 2011. ISBN 10: 0849310911
4. Manolakis, Dimitris G., and Vinay K. Ingle. *Applied Digital Signal Processing: Theory and Practice*, 1st edition, Cambridge University Press, 2011. ISBN-13: 978-0521110020

23-203-0511 COMMUNICATION LABORATORY

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able

1. To design circuits of different analog modulation techniques like AM, FM etc., its generation and demodulation.
2. To design different pulse modulation techniques like PAM, generation and demodulation
3. To simulate digital communication systems and evaluate its performance

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	3	3	2	1	1			2	1	1	1	3	2
CO 2	3	3	3	2	1	1			2	1	1	1	3	2
CO 3	3	3	3	3	1	1			2	1	1	1	1	3

1-Slightly; 2-Moderately; 3-Substantially

Experiments:

1. Amplitude modulation and demodulation
2. Frequency modulation
3. PAM modulator and demodulator
4. Simulation of digital and analog communication systems
5. Error correction & coding & LPDC, Viterbi algorithm
6. Digital modulation techniques and it performance measures
7. Matched filter receiver for rectangular pulse.

References:

1. John G. Proakis,Masoud Salehi, Gerhard Bauch, *Contemporary Communication Systems Using MATLAB*, Cengage Learning, Third Edition, ISBN 1133707033, 9781133707035, 2012.
2. Lathi, B.P., and Zhi Ding. *Modern Digital and Analog Communication Systems*, 5th edition, Oxford University Press, 2018 ISBN 978-0-19-538493-2

23-203-0512 INTERNSHIP-II

Course Outcomes:
On completion of this course the student will be able to:

1. Understand the real time technical/managerial skills required and relevant to the subject area of internship.
2. Initiate a habit of proper daily diary writing with adequacy and quality of information recorded, drawing and sketches and data, thought process and the proper organization of the information gained during the internship.
3. Conceive the pros and cons of working in a real time industrial environment and the wonderful results which could evolve through team-work.
4. Present and defend self-prepared and corrected internship reports (with the help of internship guide/industry mentors) of a self-created work to a peer audience.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	**1**					**1**	**2**	**3**				**3**		
CO 2		**1**	**1**			**3**	**1**	**2**	**2**	**3**		**3**		
CO 3	**2**	**2**	**1**		**3**	**1**	**2**	**3**	**1**	**1**	**2**	**2**		
CO 4						**2**			**3**	**2**	**2**	**1**		

1-Slightly; 2-Moderately; 3-Substantially

Internship Guidelines

- An internship plan has to be prepared by the interns incorporating the job description/internship duties, name of the project, if any and internship schedule and expected learning outcomes in consultation with industry supervisor/mentor and institute faculty.
- A detailed training report in the prescribed format shall be submitted at the end of the internship.
- Training Certificate from the industry for the prescribed period shall be submitted at the end of the internship.
- The work shall be reviewed and evaluated periodically.
- Orientation of interns, resource requirement of interns, monitoring of intern's progress on a daily basis shall be carried out by the industry offering internship in addition to ensuring safety and welfare of the interns.

A committee consisting of the Internship Coordinator (nominated by the Head of the Department/Division), faculty mentor, and at least one senior faculty member must be assigned to evaluate the work.

Guidelines for evaluation:

Regularity and progress of work	10
Work knowledge and involvement	10
Semester End presentation and oral Examination	10
Level of completion of internship	10
Internship Report-Presentation style and content	10
Total	**50** Marks

SEMESTER VI
23-203-0601 INFORMATION THEORY AND CODING

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to:

1. Understand about Entropy and Loss-less Source Coding
2. Understand the concepts of Channel Capacity and Coding Theorem
3. Understand different linear block codes and decoding techniques
4. Understand the different convolutional codes

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	**3**	**3**				**1**	**1**					**1**	**2**	
CO 2	**3**	**3**				**1**	**1**					**1**	**2**	
CO 3	**3**	**3**	**1**		**1**	**1**	**1**					**1**	**2**	**1**
CO 4	**3**	**3**	**1**		**1**	**1**	**1**					**1**	**2**	**1**

1-Slightly; 2-Moderately; 3-Substantially

Module I

Entropy and Loss-less Source Coding: Entropy, Entropy of discrete random variables- Joint, conditional and relative entropy- Chain rule for entropy, Mutual information and conditional mutual information, Relative entropy and mutual Information Lossless source coding- Discrete Memory-less sources, Uniquely decodable codes- Instantaneous codes- Kraft's inequality – Average code word length, Optimal codes- Huffman coding, Arithmetic Coding, Shannon's Source Coding Theorem.

Module II

Channel Capacity and Coding Theorem: Channel Capacity- Discrete memory-less channels (DMC) and channel transition probabilities, Capacity computation for simple channels- Shannon's Channel Coding Theorem, Converse of Channel Coding Theorem.

Module III

Continuous Sources and Channels: Differential Entropy- Mutual information- Waveform channels- Gaussian channels- Shannon- Hartley Theorem, Shannon limit, efficiency of digital modulation schemes-power limited and bandwidth limited systems.

Module IV

Coding - linear block codes-generator matrices-parity check matrices-encoder-syndrome and error correction-minimum distance-error correction and error detection capabilities - cyclic codes-coding and decoding. Convolutional codes-encoder -state diagram-distance properties- maximum likelihood decoding-viterbi decoding.

Text books:

1. Johnson, Oliver. *Information Theory and the Central Limit Theorem*, 2nd edition, World Scientific Publishing, 2021. ISBN 981-02-4322-7. 21
2. John P Proakis & Salehi, *Digital Communication*, McGrawHill,5/e, (2008), ISBN 780070591172.

References:

3. Thomas M. Cover and Joy A. Thomas, *Elements of Information Theory*, Wiley India, ISBN 9788126508143.
4. Ryan, William E., and Shu Lin. *Channel Codes: Classical and Modern*, 2nd edition, Cambridge University Press, 2021. ISBN 978-0-521-84868-8
5. Ranjan Bose, *Information Theory, Coding and Cryptography*, Tata McGraw-Hill, 2/e, (2008) ISBN-13. 978-0070151512

23-203 -0602 DIGITAL IMAGE PROCESSING

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to:

1. Acquire knowledge about the fundamentals of digital images and transforms
2. Enhance and restore images in spatial and frequency domain
3. Apply morphological and segmentation techniques to images
4. Understand the basics of colour image processing and be able to extract features from digital images.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	2			2	1		2		1		1	3	
CO 2	3	2		1	2	1		2		1		1	2	2
CO 3	3	2		1	2	1		2		1		1	2	2
CO 4	3	2			2	1		2		1		1	2	2

1-Slightly; 2-Moderately; 3-Substantially

Module I

Digital Image Fundamentals: Different imaging modalities, Representation of digital image -Elements of visual perception – Image sampling and quantization- Basic relationship between pixels.

Matrix based transforms: 2D DFT, Hadamard, DCT, Wavelet Transforms.

Module II

Image Enhancement: Spatial domain methods: Basic Gray Level Transformations-Histogram Processing: Equalization and specification- Fundamentals of Spatial Filtering: Smoothing, Sharpening spatial filters. Frequency domain methods: low pass filtering, high pass filtering, Homomorphic filtering.

Image Restoration: Degradation Model- Restoration in the presence of Noise only -Spatial Filtering –Inverse filtering - Wiener filter

Module III

Morphological Image Processing: The structuring element, Basic operations on sets, Erosion, Dilation, Opening and Closing

Image segmentation: Detection of discontinuities: Point Line and Edge Detection - Edge linking and boundary detection - Hough transform – Thresholding - Region based segmentation: Region growing -Region splitting and merging - Use of motion in segmentation-spatial domain approaches

Module IV

Feature Extraction: Boundary Preprocessing, Boundary Feature Descriptors, Region Feature Descriptors- Topological descriptors.

Fundamentals of Colour image processing: Colour models - RGB, CMY, HSI - Pseudo colour image processing - intensity slicing, gray level to color transformation.

Text books:

1. Gonzalez and Woods, *Digital Image Processing*, Pearson Education,4/e, (2021) ISBN 978-0-13-335672-4
2. Anil K. Jain, *Fundamentals of Digital Image Processing*, Prentice Hall India, (2015). ISBN 9780133325782.

References:

3. D. Sundararajan, *Digital Image Processing: A Signal Processing and Algorithmic Approach*, Springer Nature, ISBN:9789811061134, 9811061130, (2017).
4. Jähne, Bernd. *Digital Image Processing: Concepts, Algorithms, and Scientific Applications*, 9th edition, Springer, 2021.
5. Mandal, Jyotsna Kumar and Baidyanath Chakravarty. *Digital Image Processing: An Algorithmic Approach*, 1st edition, Springer, 2021

23-203-0603 CONTROL SYSTEM

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to:

1. Analyze control systems using mathematical model ·
2. Determine the response of different order systems for various inputs
3. Analyze the stability of the analog control system
4. Understand state space analysis and solve state equations.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO 2
CO 1	3	3	3	2	1							1	3	
CO 2	3	3	3	3	3	2	2	2	2	2	1	1	2	2
CO 3	3	3	3	3	3							1	3	
CO 4	3	3	2	1	1							1	2	

1-Slightly; 2-Moderately; 3-Substantially

Module I - General schematic diagram of control systems - open loop and closed loop systems – concept of feedback - Review of Laplace transform - Mathematical modelling of control systems - Electrical Systems and mechanical translational systems - transfer function – Electrical analogous of mechanical translational systems - block diagrams representation and reduction methods - signal flow graph - mason's gain formula

Module II - Analysis of continuous time systems - time domain solution of first order systems – time constant, time domain specifications - time domain solution of second order systems – damping ratio - response of second order systems for step input - steady state error and static error coefficients for standard inputs - concept of stability –location of roots on the s plane - Routh- Hurwitz techniques - construction of root locus

Module III - Frequency response analysis – construction of bode diagrams - phase margin - gain margin - polar plots - theory of Nyquist stability criterion - Theory of lag, lead and lag- lead compensators.

Module IV - Introduction to the state variable concept - state space models for continuous time systems - phase variables - solution of state equations - homogenous and non-homogenous cases - properties of state transition matrix - Concepts of Controllability and Observability - Kalman's Test.

Text books:

1. Gopal, M. *Control Systems: Principles and Design*, 5th edition, McGraw-Hill Education, 2020. ISBN-10: 9780071333269

References:

2. Dorf, Richard C., and Robert H. Bishop. *Modern Control Systems*, 14th edition, Pearson, 2022. ISBN, 013730725X, 9780137307258
3. K. Ogata, *Modern Control Engineering* Prentice Hall of India, 5/e, (2010) ISBN, 0136156738, 9780136156734
4. Norman S. Nise, *Control Systems Engineering* John Wiley and Sons Inc, 4/e, ISBN 9788126510979,2019
5. Kuo, Benjamin C., and Farid Golnaraghi. *Automatic Control Systems*, 10th edition, McGraw-Hill Education, 2017.

23-203-0604 ANTENNA THEORY

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to:

1. Understand basic terminology, parameters and concepts of Antennas
2. Analyze the electric and magnetic field of various basic antennas
3. Analyse the performance of Antenna Arrays
4. Acquire knowledge on antenna types as well as their application
5. Understand the propagation of the waves at different frequencies through different layers of atmosphere

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	2			1		1	1		1		1	3	
CO 2	3	3	1		1	1	1					1	2	2
CO 3	3	3	2	2	1		1	1		1		1	2	2
CO 4	3	2			1		1	1		1		1	2	
CO 5	3	2					1	1		1		1	2	

1-Slightly; 2-Moderately; 3-Substantially

Module I

Radiation Mechanism, Antenna parameters: Radiation Pattern, Radiation Power Density, Radiation Intensity, Beamwidth, Directivity, Antenna Efficiency, Gain, Beam Efficiency, Bandwidth, Polarization, Input Impedance, Antenna Radiation Efficiency, Effective aperture area.Radiation Integrals and Auxiliary Potential Functions: The Vector Potential A for an Electric Current Source J, The Vector Potential F for a Magnetic Current Source.

Module II

Radiation from an infinitesimal dipole, total power radiated and its radiation resistance. Radiation from half wave dipole radiation fields and its radiation resistance. Near field and far field. Small loop antennas. Antenna arrays: Point Sources - arrays of 2 Isotropic Sources and N element point sources, Principle of Pattern Multiplication, Uniform Linear Arrays - Broadside Arrays, End fire Arrays.

Module III

Types of antennas: Yagi-Uda Antenna, Helical Antenna - Axial mode helix, Normal mode helix, Biconical Antenna, Log periodic Dipole Array, Microwave antennas: Horn antennas, E plane and H plane Sectoral Horn, Parabolic reflector, Microstrip Patch Antennas – Radiation Mechanism, Radiation Pattern, Design of Rectangular Patch Antenna.

Module IV

Fundamentals of Wave propagation: Ground waves, Space waves and Sky wave. Free space propagation, Frii's Transmission Equation, Path loss, Plane earth loss, Spherical earth effects, Multipath Effects, Tropospheric refraction, Path profiles - Line of sight versus non-line of sight. Refraction and Reflection of sky waves by ionosphere – ray paths – skip distance – virtual height-critical frequency- maximum usable frequency -vertical and oblique incidence.

Text books:

1. C. A Balanis, *Antenna Theory: Analysis and design*, John Wiley, 4/e, (2016), ISBN:978-1-118-64206-1
2. J.D. Kraus, R. J Marhefka, Ahmed S Khan, *Antennas and wave propagation*, McGraw Hill India, 5/e, (2017) ISBN-13. 978-9352606184

References:

3.Jordan and Balmain, *Electromagnetic waves and Radiating systems*, PHI 2/e, 2015, ISBN -13:978-9332551770

4.G.S.N Raju, *Antennas and Wave Propagation*, Pearson education, 2012, ISBN-13: 978- 8131701843

5. Sisir K Das and Annapurna Das, "*Antenna and Wave Propagation*," McGraw Hill Education India Private limited, 2017. ISBN: 978-1-25-900632-6

6. Warren L. Stutzman and Gary A. Thiele, *Antenna Theory and Design,* 4th Edition, 2021

23-203-0605 (IE) INTRODUCTION TO MACHINE LEARNING

Course outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able

1. To understand various machine learning techniques
2. To develop artificial neural network models for different machine learning applications
3. To understand dimensionality reduction techniques and decision trees.
4. To apply different clustering methods and its evaluation in practical scenario

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	1	1	1								3	2	1
CO 2	3	3	3	2								3	2	3
CO 3	3	1	1	2								3	2	2
CO 4	3	3	3	3								3	2	2

1-Slightly; 2-Moderately; 3-Substantially

Module I

Introduction: Machine Learning, Applications, Types of Machine Learning-Supervised Learning: Classification, Regression, Unsupervised Learning, Reinforcement Learning,
Bayes Theorem, Bayesian classifier
Building a Machine Learning Model

Module II

Introduction to Artificial neural networks: Biological Neuron, McCulloch Pitts Model, Perceptron, training a perceptron, Implementing Boolean functions, Multilayer Perceptrons, Backpropagation Algorithm, Classification- Cross validation and re-sampling methods- Kfold cross validation, Measuring classifier performance- F1 score, Precision, recall, ROC curves.

Module III

Dimensionality Reduction: Introduction, Subset Selection, Principal Components Analysis, Factor Analysis, Multidimensional Scaling, Linear Discriminant Analysis, Locally Linear Embedding, Decision Trees: Introduction, Univariate Trees, Pruning, Rule Extraction from Trees, Learning Rules from Data, Multivariate Trees

Module IV

Clustering: Introduction, k-Means Clustering, Expectation-Maximization Algorithm, Mixtures of Latent Variable Models, Supervised Learning after Clustering, Hierarchical Clustering, Dendrograms, Choosing the Number of Clusters.

Text books:

1. Christopher M. Bishop, *Pattern Recognition and Machine Learning*, Springer, 2/e, 2020. ISBN-13: 978-0387310732
2. Ethem Alpaydin, *Introduction to Machine Learning*, Second Edition, 2010. ISBN 978-0-262-01243-0

References:

3. Stephen Marsland, *MACHINE LEARNING An Algorithmic Perspective*, 2nd Edition, CRC Press, 2015. ISBN 10: 1466583282
4. Kevin P. Murphy, *Machine Learning: A Probabilistic Perspective*, 2nd Edition, 2021, ISBN 0262044668, 9780262044660

23-203-0606 SATELLITE COMMUNICATION

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to:

1. Understand the basics of satellite orbits.
2. Understand the satellite segment and earth segment.
3. Analyze the various methods of satellite access.
4. Understand the applications of satellites**.**

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	2					1	1		1		1	2	1
CO 2	3	2					1	1		1		1	2	1
CO 3	3	3					1	1		1		1	2	1
CO 4	3	2					1	1		1		1	2	1

1-Slightly; 2-Moderately; 3-Substantially

Module I

Kepler's Laws, Newton's law, orbital parameters, orbital perturbations, station keeping, geo stationary and non-Geo-stationary orbits – Look Angle Determination- Limits of visibility –Eclipse-Sub satellite point –Sun transit Outage-Launching Procedures - launch vehicles and propulsion.

Module II

Spacecraft Technology- Structure, Primary power, Attitude and Orbit control, Thermal control and Propulsion, communication Payload and supporting subsystems, Telemetry, Tracking and command. Satellite uplink and downlink Analysis and Design, link budget, E/N calculation- performance impairments-system noise, inter modulation noise and interference, Propagation Characteristics and Frequency considerations- System reliability and design lifetime.

Module III

Receive – Only home TV systems – Outdoor unit – Indoor unit for analog (FM) TV – Master antenna TV system – Community antenna TV system – Transmit – Receive earth stations – Problems – Equivalent isotropic radiated power – Transmission losses – Free-space transmission – Feeder losses – Antenna misalignment losses – Fixed atmospheric and ionospheric losses – Link power budget equation – System noise – Antenna noise – Amplifier noise temperature – Amplifiers in cascade – Noise factor – Noise temperature of absorptive networks – Overall system noise temperature – Carrierto- Noise ratio – Uplink

– Saturation flux density – Input back off – The earth station - HPA – Downlink – Output back off – Satellite TWTA output – Effects of rain – Uplink rain– Fade margin – Downlink rain – Fade margin – Combined uplink and downlink C/N ratio.

Module IV

Modulation and Multiplexing: Voice, Data, Video, Analog – digital transmission system, Digital video Broadcast, multiple access: FDMA, TDMA, CDMA, Assignment Methods, Spread Spectrum communication, compression – encryption. Satellite Applications: INTELSAT Series, LEO, MEO, Satellite Navigational Systems. Direct Broadcast satellites (DBS)-Direct to home Broadcast (DTH)

Text book:

1. M.Richharia, *Satellite Communication Systems-Design Principles*, Macmillan 2003. ISBN 0133023893 9780133023893

References:

2. Dennis Roddy, *Satellite Communication*, 4th Edition, Mc Graw Hill International, 2017, ISBN 978-0070077850.
3. Wilbur L.Pritchard, Hendri G. Suyderhoud, Robert A. Nelson, *Satellite Communication Systems Engineering*, Prentice Hall/Pearson, 2007.
4. Gerard Maral and Michel Bousquet, *Satellite Communications Systems: Systems, Techniques and Technology,* 6th Edition, 2020, ISBN-13: 978-1119382089
5. Bruce R. Elbert, *The Satellite Communication Applications Hand Book*, Artech House, 1997.
6. Tri T. Ha, Digital Satellite Communication, McGraw Hill, 2/e, 2017, ISBN 978-0070077522.
7. Anil K. Maini and Varsha Agrawal, *Satellite Communications: Principles and Applications,* 3rd Edition, 2021 ISBN: 978-1-118-63647-3

23-203-0607 FLEXIBLE ELECTRONICS

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to

1. Understand the techniques, materials and fabrication of flexible electronics.
2. Realize the role of CNT in flexible electronics, its challenges and recent progress.
3. Understand flexible hybrid electronics
4. Realize the applications of flexible electronics technology

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	**3**	**1**	**1**									**1**	**3**	
CO 2	**3**	**1**	**1**									**1**	**2**	
CO 3	**3**	**1**	**1**									**1**	**3**	
CO 4	**3**	**1**	**1**									**1**	**2**	**1**

1-Slightly; 2-Moderately; 3-Substantially

Module-I

Flexible, Wearable, and Stretchable Electronics

Introduction, Functional electronic components and devices, Thin film transistors(TFT)-Carbon nanotube based TFT, Organic TFT, Displays, Sensors, Batteries, Bio-Integrated electronics

Module II

Stretchable Conductor, Components and Devices

Substrate and conductive materials, Stretchable structures, applications, Electrical components and circuits-resistors, capacitors, transistors, IC, photovoltaics, luminescent devices-principles, materials and fabrication

Module III

Carbon Nanotube-Based Flexible Electronics

Carbon nanotube based -flexible TFTs, flexible CMOS circuits, flexible sensors. Flexible Sensor Sheets for Healthcare Applications- ECG and skin temperature sensor, CCD based flexible pH sensor, Flexible Hybrid Electronics (FHE)-Concept and fabrication

Module IV

Flexible and Stretchable Systems for Healthcare and Mobility

Core technologies for flexible/stretchable system integration, Ultrathin flexible circuits and systems, stretchable circuits and systems, conformally integrated electronics, application examples

Text book:

1. Katsuyuki Sakuma, *Flexible, wearable and stretchable electronics*- CRC Press, 2020, Taylor & Francis ISBN 9780429263941

References:

2. William S. Wong and Alberto Salleo, *Flexible Electronics: Materials and Applications* (2nd Edition, 2021) ISBN: 9780849308260
3. Ramses V Martinez, *Flexible Electronics: Fabrication and Ubiquitous Integration,* Mdpi AG, 2019.

23-203-0608 ELECTRONIC MEASUREMENTS & INSTRUMENTATION

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to:

1. Analyse the errors in measurements and their rectification.
2. Understand the different transducers used in measurements
3. Understand different techniques used for parameter measurements
4. Study different types of signal generators and analysers

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	2	1	2	1							1	2	2
CO 2	3	1	1		1							1	3	
CO 3	3	1	1		1							1	3	
CO 4	3	1	1		1							1	2	

1-Slightly; 2-Moderately; 3-Substantially

Module-I

Introduction – Measurements - Monitoring, Control, Analysis. Instruments- Transducer, Signal Conditioner and Transmitter, Display/Recording Devices. Static characteristics of Instruments. Estimation of Static errors and reliability-errors, types of errors, probability of errors, limiting errors, Reliability Principles. Dynamic characteristics of Instruments-Transfer Function-Zero, first and second order Instruments-Dynamic response of first and second order Instruments.

Module II

Transducers and Sensors: Transducers- active and passive, Selection Criteria- Smart Sensors and IEEE 1451 Standard. Temperature measurements-RTD, Thermocouples. Displacement Measurement- LVDT. Strain Measurement. Measurement of acceleration, force, and Torque. Piezo-electric transducers.

Module III

Industrial instrumentation: Sample and hold, ADC, DAC, Pressure Measurement- Flow Measurements Level Measurement. Bridge measurements:-DC bridges for low, medium and high resistance-ac bridges for capacitance and inductance. Vector impedance meter, Multimeters: - Principles of analog and digital multimeters, Digital storage oscilloscope (DSO). Recording instruments- Strip chart recorders, x-y- recorders

Module IV

Signal generators: - Sine-wave Generators-AF and RF Signal Generators- Non-sinusoidal Generators, Function generator-Sweep frequency generator- Frequency synthesizers. Digital Signal Generators- Arbitrary Wave form Generator, Data Generator. Signal analyzers-Wave Analyzer –Harmonic Distortion Analyzer, Spectrum Analyzer. FFT Analyzer, Vector Analyzer, Logic Analyzer, Data Acquisition Systems:Types, Telemetry, Virtual Instrumentation Systems

Text book:

1.R.K. Rajput, *Electronic Measurements and Instrumentation,* 5th Edition, 2021.

References:

1. M. M. S Anand, *Electronic Instruments and Instrumentation technology*, PHI Learning Pvt.Ltd, India, (2018). ISBN-10. 8120324544
2. Alan S. Morris and Reza Langari, *Measurement and Instrumentation: Theory and Application* (3rd Edition, 2021) ISBN: 9780128171417
3. David A. Bell and Ranjan Bose, *Electronic Instrumentation and Measurements* (3rd Edition, 2021) ISBN-10: 1905944209
4. K. Lal Kishore, *Electronic Measurements and Instrumentation* (2nd Edition, 2019) ISBN-13: 978-8177001006
5. D. Patranabis, *Sensors and Transducers* (3rd Edition, 2020) ISBN: 9780750649322

23-203-0609 ADVANCED DIGITAL SYSTEM DESIGN

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to:

1. Understand the design of asynchronous sequential circuit
2. Understand verification guidelines for using System Verilog language
3. Understand data types, Procedural statements and routines, Basic OOP concepts.
4. Build a test bench and connect it to design under test
5. Create threads in testbench and use interprocess communication

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	2	2									1	3	
CO 2	3	2	2									1	2	
CO 3	3	3	2									1	3	
CO 4	3	3	2									1	2	2
CO 5	3	3	2									1	2	2

1-Slightly; 2-Moderately; 3-Substantially

Module I

Asynchronous Sequential Circuit Design

Analysis of asynchronous sequential circuit – flow table reduction-races-state assignment- transition table and problems in transition table- design of asynchronous sequential Circuit-Static, dynamic and essential hazards – designing vending machine controller. Familiarization with data sheets-digital logic levels (at least one lab session may be included).

Module II

Verification guidelines

Introduction, Verification process,Verification plan, Basic testbench functionality, Directed testing, Constrained random stimulus, Functional coverage, Testbench components, Layered Testbench, Building a layered Testbench,Simulation environment phases, Testbench performance

Module III

Data types, Procedural statements, Tasks, Functions and Void Functions,Routine arguments, Local data storage, Time values. Basic OOP-Creating objects,Using objects, Class routines, Scoping rules, Dynamic objects, Copying objects,Public vs. Private, Building a test bench

Module IV

Separating the test bench and design, The Interface construct, Stimulus timing, Interface driving and sampling, Top level scope, Program module interactions, SystemVerilog assertions, Randomization in SystemVerilog, Working with threads, Inter process communication

Text books:

1.Charles H. Roth Jr, *Fundamentals of Logic Design* Thomson Learning, 7/e, (2013) ISBN, 1285633024

2. Chris Spear, *System Verilog for Verification-A Guide to Learning the Testbench Language Features*, Springer ISBN-13: 978-1461407140

References:

3. Samir Palnitkar, *Verilog HDL*, Pearson Education, 2011 ISBN: 9780132599702
4. Parag K. Lala, *Digital system Design using PLD,* B S Publications, (2003) ISBN-13: 978-8178000398
5. Rao P. Niranjan, *Digital Systems Design using VHDL* (3rd Edition, 2020)

23-203-0610 COMMUNICATION SYSTEMS

Course outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to:

1. Understand microwave communication & microwave link design
2. Understand satellite communication, transponder & satellite application
3. Understand basic concept of wireless communications systems such as CDMA & communication standards

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	3	1				1	1		1		1	3	
CO 2	3	3	1				1	1		1		1	3	
CO 3	3	3	1				1	1		1		1	2	1

1-Slightly; 2-Moderately; 3-Substantially

Module 1

Microwave Communication: Basic principles of microwave links- Microwave Relay Systems – Choice of frequency – line of sight and over the horizon systems – modulation methods – block schematics of terminal transmitters and receivers – microwave repeaters – microwave antennas – propagation mechanisms – path loss models – shadowing models – small scale fading and multipath fading – basic principles of design of microwave link

Module II

Satellite Communication – Orbit of communication satellite – Satellite Constellation – Orbital parameters – Orbital perturbations – Geostationary orbits – Low Earth and Medium Orbits – Look Angles – Frequency selection RF Links – Propagation characteristics – Modulation methods – multiple access – spacecraft – antennas – transponders – intersatellite link – link power budget – earth station interference – Satellite systems – Geostationary systems – Distress and Safety systems – Navigation systems – direct sound broadcast systems – Direct Television broadcast systems.

Module III

Wireless communication systems: Cellular concepts – Cell Splitting and Frequency Reuse - Propagation Mechanisms – Modulation techniques for wireless communication – Analog, Digital and Spread Spectrum modulation – Equalization, Diversity and Channel Coding Diversity Techniques – Multiple access techniques for Wireless Communications – FDMA, TDMA and CDMA – Comparison of wireless standards from 1G to 5G.

Module IV

Spread system Communication: General concepts – Direct Sequence spread spectrum – frequency hopping – transmitter and receiver – time hopping – Antijam consideration – CDMA Telemetry and Remote Sensing: Definition of telemetry – different types – Applications – Image characteristics – Contrast Ratio – Spatial Resolution – Resolving Power – brightness – tones etc. – Remote Sensing Systems – Framing systems – Scanning systems – characteristics of aerial photographs – spatial and ground resolution – relief displacement etc – IR detection and imaging – IR image characteristics – Applications of Remote Sensing.

Text books:

1. T.S. Rappaport, *Wireless Digital Communications: Principles and Practice*, Pearson Education/ Prentice Hall, 3/e, 2020 ISBN, 9332576165
2. Schiller, *Mobile Communications*, Pearson Education, 3/e, 2021 ISBN-13. 978-8131724262

References:

3. WL Prichard, *Satellite Communication Systems Engineering*, Pearson Education, 2015 ISBN-13: 978-0137914685
4. B P Lathi, *Analog and Digital Communication*, Oxford University Press, 2018 ISBN: 9780190686840
5. Thomas M. Lillesand, Ralph W. Kiefer, and Jonathan W. Chipman, *Remote Sensing and Image Interpretation*, WH Freeman & C, New York, 8/e, 2021 ISBN: 978-1-118-34328-9
6. Anil K. Maini and Varsha Agrawal, *Satellite Communications: Principles and Applications* (3rd Edition, 2021) ISBN: 978-1-118-63647

23-203-0611 NON-CONVENTIONAL SOURCES OF ENERGY

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to

1. Identify social, political, economic and environmental issues associated with adoption and use of renewable energy technologies in modern societies and historical implications
2. Perform calculations to analyze solar radiation availability, determine appropriate solar collector orientations, estimate power potential from wind and other renewable sources
3. Recognize alternative options for renewable energy within the context of overall energy consumption patterns, costs, effects on ecosystems, and sustainability considerations to enable informed personal and public decision-making

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	1								1		3	2	
CO 2	3	2								1		3	2	1
CO 3	3	2								1		3	2	

1-Slightly; 2-Moderately; 3-Substantially

Module I

Principles of solar radiation: Role and potential of new and renewable source, the solar energy option, Environmental impact of solar power, physics of the sun, the solar constant, extra- terrestrial and terrestrial solar radiation, solar radiation on titled surface, instruments for measuring solar radiation and sun shine, solar radiation data.

Solar energy collection: Flat plate and concentrating collectors, classification of concentrating collectors, orientation and thermal analysis, advanced collectors.

Solar energy storage and applications: Different methods, Sensible, latent heat and stratified storage, solar ponds. Solar Applications- solar heating/cooling technique, solar distillation and drying, photovoltaic energy conversion.

Module II

Wind energy: Sources and potentials, horizontal and vertical axis windmills, performance characteristics, Betz criteria **Bio-mass:** Principles of Bio-Conversion, Anaerobic/aerobic digestion, types of Bio-gas digesters, gas yield, combustion characteristics of bio-gas, utilization for cooking, I.C. Engine operation and economic aspects.

Module III

Geothermal energy: Resources, types of wells, methods of harnessing the energy, potential in India. **Ocean energy**: OTEC, Principles utilization, setting of OTEC plants, thermodynamic cycles. Tidal and wave energy: Potential and conversion techniques, mini-hydel power plants, and their economics.

Module IV

Direct energy conversion: Need for DEC, Carnot cycle, limitations, principles of DEC. Thermoelectric generators, seebeck, Peltier and joule Thomson effects, Figure of merit, materials, applications, MHD generators, principles, dissociation and ionization, hall effect, magnetic flux, MHD accelerator, MHD Engine, power generation systems, electron gas dynamic conversion, economic aspects. Fuel cells, principles, faraday's law's, thermodynamic aspects, selection of fuels and operating conditions.

Text books:

1. B H Khan, *Non-Conventional Energy Resources,* McGraw Hill India, 2020. ISBN-10. 9789352601882
2. John Andrews and Nick Jelley, *Energy Science-Principles, Technologies, and Impacts*, 4/e, Oxford press, 2022, ISBN: 9780198854401

References:

3. Manoj Kumar Ghosal. *Renewable Energy Technologies*, Narosa Publishing House, 2018. ISBN: 978-81-8487-581-2
4. V.V. Desai and Nikhil Golder, *Renewable Energy Engineering and Technology: Principles and Practice* (1st Edition, 2018)
5. Ashok V Desai, *Non-Conventional Energy,* New Age International Private Limited; Second edition, 2022 ISBN-10. 8122402070
6. D.P. Kothari, K.C. Singal, and Rakesh Ranjan, *Renewable Energy Sources and Emerging Technologies* (3rd Edition, 2019) ISBN: 978812034 4 709
7. S. P. Sukhatme, J K. Nayak, *Solar Energy*, 4th Edition, 2017, 9352607112, 9789352607112.

23-203-0612 MEMS AND NEMS

Course Objectives:

At the end of the course students will be able to:

1. Understand the working principles and applications of micro and nano devices and systems
2. Analyse appropriate integration and packaging approaches for MEMS/NEMS
3. Understand and design bio-MEMS sensors
4. Distinguish between classical and quantum mechanics
5. Design micro devices using MEMS fabrication processes

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	1	1									1	3	
CO 2	3	1	1									1	2	
CO 3	3	3	2									1	3	1
CO 4	3	1	3									1	2	
CO 5	3	3	1									1	2	1

1-Slightly; 2-Moderately; 3-Substantially

Module I:

Introduction to MEMS and NEMS: Overview of MEMS, NEMS and applications; Scaling laws; Materials for MEMS and NEMS- Silicon, metals, polymers, ceramics; Micro and nanofabrication techniques- Photolithography, etching, deposition, bonding

Module II:

MEMS Transducers and Microsystems: MEMS sensors: mechanical -pressure, inertial, ultrasonic; thermal, optical-MOEMS, radiation, chemical and biological sensors, Design principles; MEMS actuators: electrostatic, thermal, magnetic, SMA based actuators Microfluidics, Optical MEMS, RF MEMS, Power MEMS

Module III:

BioMEMS and Nanosystems: BioMEMS: DNA microarrays, lab-on-a-chip, μTAS, Nanopore sensors, Design of bioMEMS Introduction to Nanosystems: Nanoelectronics and nanophotonics devices, Carbon nanotubes, nanowires, Atomic and molecular scale systems, Introduction to Quantum Mechanics: Wave functions, Schrödinger equation, Quantum physics of nanosystems

Module IV:

Packaging, Manufacturing and CAD for MEMS/NEMS: Packaging of MEMS: Hermetic and non-hermetic packaging, Wafer bonding, Adhesives, Reliability testing, Manufacturing and Process Integration of MEMS, Testing of MEMS: Optical inspection, Scanning probe microscopy, Functional testing CAD/CAE tools for MEMS/NEMS

Text books:

1. Sergey Edward Lyshevski, *MEMS and NEMS: Systems, Devices and Structures, Nano and Micro Science Engineering*, Technology and Medicine Series, CRC Press, 2018
2. Marc J. Madou, *Fundamentals of Microfabrication and Nanotechnology*, CRC press, 4th Edition (2019), ISBN 9781315274164

References:

3. Mark Hong, *Principles and Applications of Micro and Nanoscale Devices* CRC press, (2021), ISBN 9781003220602
4. Albert Folch, *Introduction to BioMEMS,* CRC press, (2nd Edition) 2016, ISBN 978-1439818398
5. Wanjun Wang, Steven A Soper, *BioMEMS: Technologies and Applications*, CRC Press, ISBN-10: 0-8493-3532-9
6. Reza Ghodssi, Pinyin Lin, *MEMS Materials and Processes Handbook*, Springer, ISBN 978-0-387-47316-1
7. Jan G. Korvink, Oliver Paul, and Dietmar Petersen, *MEMS: A Practical Guide to Design, Analysis, and Applications* (3rd Edition, 2022)

23-203-0613 MINOR PROJECT BASED ON EMBEDDED SYSTEMS

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able

1. Understand the constituents of an embedded systems
2. Utilize modern hardware/software tools for building prototypes of embedded system
3. Develop embedded systems with specifications and technological choice
4. Understand the basics of embedded operating system and its management

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	**3**	**2**	**2**		**2**				**3**	**2**		**2**	**3**	
CO 2	**3**	**2**	**2**		**2**				**3**	**2**		**2**	**2**	**2**
CO 3	**3**	**2**	**2**		**2**				**3**	**2**		**2**	**2**	**3**
CO 4	**3**	**2**	**2**		**2**				**3**	**2**		**2**	**2**	

1-Slightly; 2-Moderately; 3-Substantially

The project team shall identify an innovative product, process or technology and proceed with detailed design based on the above study. Each batch of 3 to 5 students shall design, develop and realize a complete Embedded system. Each student shall submit a project report at the end of the semester. The project report should contain the design and engineering documentation including the Bill of Materials, list of softwares, algorithms used and test results. Project has to be demonstrated for its full design specifications. Innovative design concepts, reliability considerations and aesthetics / ergonomic aspects, published paper, patents etc. taken care of in the project shall be given due weight.

Guidelines for evaluation:

CE- Continuous evaluation -Level of completion	20 + 5
SE - End-Semester presentation, Oral Examination, documentation and demonstration	10+5+5+5
Total	50 marks

23-203-0614 MICROWAVE ENGINEERING LABORATORY

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able

1. To design and simulate different Microwave systems.
2. To understand and perform experiments using microwave bench

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	3	3	3	3	1		2	2	1	1	1	2	3
CO 2	2								2			1	3	

1-Slightly; 2-Moderately; 3-Substantially

Experiments:

1. Determine the Reflex Klystron frequency and mode characteristics
2. Obtain the characteristics of crystal detector
3. Measurement of guide wavelength and source frequency
4. Study of V-I characteristics of GUNN diode
5. Determine the Parameters of: directional coupler, isolator and circulator
6. Determine the unknown impedance using slotted section and smith chart
7. Study of: attenuators, E-plane, H-plane and Magic Tees
8. Determine the radiation patterns of E-plane sectoral, H-plane sectoral and horn antennas.
9. Study of input impedance and S parameters of various microwave networks using network analyzer.
10. Design and optimization of various microwave networks like filters and antennas using microwave simulators like HFSS, CST/IE3D/MICROWAVE STUDIO/ADS

References:

1. K.C.Raveendranathan, *Communication Systems Modelling and Simulation, Using MATLAB® and SIMULINK®*, University Press, 1/e, 2011 ISBN: 978-81-737-1722

SEMESTER VII

23-200-0701 PRINCIPLES OF MANAGEMENT

Course Outcomes:

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

1. Understand the basic principles underlying in the management of organizations.
2. Get exposure in all industrial management functions.
3. Get knowledge to analyse the financial accounts and ratios.
4. Understand the principles of economics and IPR aspects.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1						1		2		2	2	1	2	
CO 2						1		2		2	2	1	2	
CO 3		1						1	1	1	3	1	2	2
CO 4						1		2		2	3	1	2	

1-Slightly; 2-Moderately; 3-Substantially

Module I

Basic concept of Management: Introduction, definitions of managements, characteristics of management, levels of management, management skills, Scientific management - Contributions of
Gilbreth and Gantt.

Functions of Management: Planning, forecasting, organizing, staffing, directing, motivating, controlling, co-coordinating, communicating, decision making.

Organization: Introduction, definition of organization, elements of organization, process of organization, principles of organization, formal and informal organization, organization structure, types of organization structure.

Forms of Business Organization: Concept of ownership organization, types of ownership, Individual ownership, partnership, joint stock company, private and limited company, co-operative organizations, state ownership, public corporation

Module II

Production planning and control: Objectives and functions.

Production management: Structure, objectives, productivity index, modern productivity improvement techniques.

Inventory Management: Functions, classifications of inventory, basic inventory models, inventory costs, Economic order quantity (EOQ). Materials Requirement Planning – Objectives, Functions and methods.

Project Management: Functions, Characteristics, Feasibility studies, Project network analysis – PERT/CPM.

Module III

Human Resource Management: Introduction, definition, objectives, characteristics, functions, principles and organization of HR management, Recruitment, selection process and training methods, Wages and incentives, Job evaluation and merit rating, Industrial accidents-causes and related issues Marketing Management: Introduction, Functions and objectives, Marketing environment and Information, Market segmentation, Distribution channels, Consumer and Industrial markets, Consumer behaviour, Pricing methods, Sales promotion and Advertisement. Market research: Objectives and methods.

Module IV

Financial Management: Basic functions, Capital-classifications, Sources of funds, Financial accounts-types, basic concepts and importance, Financial ratios and its significance, Types of budgets and budgetary controls, Overheads, Standard costing, Marginal costing.

Economics: Principles of economics, problem of scarcity, demand, supply, utility, time value of money, inflation and deflation, Consumer Demand Curve.

IPR Aspects: General introduction to IPR, eligibility for patent, patent information and prior art search, procedure for filing patent application, rights of patent owner and duration, ownership of patent and commercialization.

Text books:

1. Fraidoon Mazda, *Engineering Management*, Addison-Wesley, (1997).
2. Koontz and O'Donnell, *Essentials of Management*, McGraw Hill, (1978).

References:

3. Kotler P., *Marketing Management*, Prentice Hall, (2011).
4. Prasanna Chandra, *Finance Management*, Tata McGraw Hill, (2008).
5. Monks, J. G., *Operations Management*, McGraw Hill, (1982).
6. R. Panneerselvam*, Production and Operations Management*, PHI (2012)

23-203 -0702 WIRELESS COMMUNICATION

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to:

1. Understand fundamental concepts of wireless propagation, cellular systems, and radio propagation models.
2. Apply techniques to calculate path loss, link budgets, and cellular coverage and utilize capacity theorems to analyze performance of digital modulation in wireless channels.
3. Investigate the impact of fading, interference, noise on wireless system performance and analyze trade-offs between coverage, capacity and reliability in wireless system design.
4. Evaluate end-to-end wireless communication systems based on requirements and constraints and propose improvements to existing wireless systems in terms of capacity, coverage or reliability.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	3				2	2	1				1	3	
CO 2	3	3				1	1			1		1	3	2
CO 3	3	3		1		1	1	1				1	2	1
CO 4	3	3		1		1	1	1				1	2	2

1-Slightly; 2-Moderately; 3-Substantially

Module I

Overview of Wireless Systems. Wireless spectrum, Signal Propagation, Path Loss Models and Shadowing, Combined Path Loss shadowing, Coverage Area, Statistical Fading Models, Narrowband Models, Signal Envelope Distribution, Fading Distributions and Duration- Wideband Fading. Doppler and Delay Spread, Wideband Channel Models.

Module II

Capacity of wireless channels- Fading Channels, Capacity of Flat and FS Fading Channels, Modulation schemes, Linear Modulation Performance in Fading, Performance in Fading and ISI. Diversity, receiver diversity, Transmit Diversity. Adaptive Modulation.

Module III

MIMO and Space/Time Communications, MIMO Capacity, Beam forming: Array factor, directivity, gain, beamwidth, sidelobe levels, Diversity, Space time codes.

Module IV

Broad Band communication: Multi carrier modulation – OFDM- spread spectrum communication- Multi user systems - random access- ALOHA, slotted ALOHA, CSMA, CSMA/CD, scheduling approaches.

Text books:

1. Goldsmith, *Wireless Communication*, Cambridge University press, (2011) ISBN 978-0521704168
2. W C Y Lee, *Mobile Communication Engineering*, Tata McGraw Hill ,2/e, (2008) ISBN 9780071336963

References:

3. Theodore S. Rappaport, *Wireless Communications: Principles and Practice*, Cambridge University press - updated 2/e (2024), ISBN- 9781009489836.
4. Haykin, Michael Moher, *Modern wireless communication*, Pearson Education, (2011), ISBN 9788131704431
5. D. Tse and P. Viswanath, *Fundamentals of Wireless Communication*, Cambridge University Press (2005), ISBN 978-0521845274
6. R. S. Kshetrimayum, *Fundamentals of MIMO Wireless Communications*, Cambridge University Press, (2017) ISBN 9781108234993

23-203-0703 (IE) IOT BASED SYSTEM DESIGN

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to:

1. Understand the basic concepts of IoT including architecture, stack, technologies, protocols, different types of sensors and interfacing used in IoT systems.
2. Implement messaging protocols (MQTT, CoAP), networking protocols (6LoWPAN) and cloud technologies for IoT.
3. Evaluate appropriate IoT architectures, technologies and platforms based on requirements such as scalability, reliability, security etc.
4. Design end-to-end IoT solutions by integrating sensors, embedded devices, networking, cloud and application software.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	3	3	3	2	3	2	1	1	1	2	1	3	
CO 2	3	1		1	2		1					1	2	
CO 3	3	2	2	2	2	2	1		1		2	1	2	
CO 4	3	1	2	2	3		1	1		1		1	2	3

1-Slightly; 2-Moderately; 3-Substantially

Module I

Introduction to IOT: Definition of IoT, Application Areas, Characteristics, IoT stack, Enabling Technologies, Challenges, IoT levels,

Introduction to sensors and Interfacing: Types of sensors, LDR sensor, ultrasound sensor, Obstacle sensors, Heartbeat sensors, GPS, Color sensor, pH sensor, Gyro sensor and its interfacing with microcontrollers.

Module II

Protocols for IoT: Messaging Protocol- MQTT, CoAP, Transport protocol- Bluetooth low energy(BLE), Light Fidelity(LiFi), Protocol for Addressing and Identification- Ipv4, Ipv6, URI

Cloud for IoT: Challenges, Selection of cloud service provider, Introduction to fog Computing, security aspects of cloud computing, Case study on cloud.

Module III

Prototyping and Designing Software for IoT Applications: introduction, Prototyping Embedded device software, Programming Embedded Device Arduino Platform using IDE, Reading data from sensors and devices, Devices, Gateways, Internet and Web/Cloud services software development.

Module IV

Python Web application Framework-Django, Amazon web services for IoT.

Case studies on: Home automations – Smart cities – Environment – Energy – Retail – Logistics – Agriculture -Industry

Text books:

1. Shriram K Vasudevan, Abhishek S Nagarajan & RMD Sundaram, *'Internet of Things'*, Wiley, 2/e (2020), ISBN 978-9388991018

2. Arshdeep Bahga and Vijay Madisetti '*Internet of Things: A Hands-on Approach'*, Orient Blackswan,1/e (2015) ISBN 978-8173719547

References:

3. Honbo Zhou, *Internet of Things in the cloud: A middleware perspective*, CRC press, 1/e (2012), ISBN 978-1439892992.

4. Adrian McEwen and Hakim Cassimally, *'Design of internet of Things'* , Wiley , 1/e (2013), ISBN 9781118430620

5. Pethuru Raj, Anupama C. Raman, *'The Internet of Things: Enabling Technologies, Platforms, and Use Cases'*Auerback Publishers, 1/e, 2017, ISBN 9781498761284

6. Raj Kamal, *'Internet of Things: Architecture And Design Principles'* McGraw Hill, std/e, (2022), ISBN 9789390727384

23-203-0704 COMPUTATIONAL ELECTROMAGNETICS

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to:

1. Understand the basics of numerical methods like FDM, MoM, FDTD, FEM for solving electromagnetic problems and concepts of discretization including basis functions, discretization error, stability, truncation and round-off errors.
2. Apply FDTD and MoM methods to analyze 1D and 2D EM propagation and scattering problems.
3. Investigate numerical dispersion, stability, and accuracy issues in FDTD, MoM and FEM solutions.
4. Analyze effects of spatial and temporal discretization on precision and computational complexity.
5. Design and optimize meshing, excitation sources, boundary conditions and post-processing for accuracy and efficiency.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	1	1	3								1	3	
CO 2	3	3	1	3								1	2	2
CO 3	3	3	2									1	2	2
CO 4	3	3	2									1	2	
CO 5	3	3	3									1	2	2

1-Slightly; 2-Moderately; 3-Substantially

Module I

Introduction: Elements of Computational Methods, Basis Functions, Sub-domain Basis Functions, Entire-domain Basis Functions, Convergence and Discretization Error Convergence Test, Order of Convergence, Discretization Error and Extrapolation, Discretization of Operators, Discretization Error in FDM, FDTD, and FEM, Stability of Numerical Solutions, Stability of FDTD Solution, Stability of Matrix Solution, Accuracy of Numerical Solutions, Modeling Errors, Truncation Error, Round-off Error, Validation, Spurious Solutions, Formulations for the Computational Methods

Module II

Method of Moments: Basis Functions, Sub-domain Basis Functions, Entire-domain Basis Functions, Point Matching and Galerkin's Methods, Eigen value Analysis using MoM. Solution of Integral Equations using MoM, Static Charge Distribution on a Wire, Analysis of Stripline, Analysis of Wire Dipole Antenna, Scattering from a Conducting Cylinder of Infinite Length, Green's functions.

Module III

Finite Difference Time Domain Analysis: FDTD Analysis in One-Dimension: Pulse Propagation in a Transmission Line, Spatial Step Δx and Numerical Dispersion, Time Step Δt and Stability of the Solution, Source or Excitation of the Grid, Absorbing Boundary Conditions, Applications of One-Dimensional FDTD Analysis, Reflection at an Interface, Determination of Propagation Constant, Design of Material Absorber, Exponential Time Stepping Algorithm in the Lossy Region, FDTD Analysis in Two-Dimensions, Unit Cell, Numerical Dispersion in Two-Dimensions, Time Step Δt for Two-Dimensional Propagation, Absorbing Boundary Conditions for Propagation in Two, Dimensions, Perfectly Matched Layer ABC's FDTD Analysis in Three-Dimension, Yee Cell, Numerical Dispersion in Three-Dimension, Time Step Δt for Three-Dimensional Propagation, Absorbing Boundary Conditions and PML for Three-Dimensions Implementation of Boundary Conditions in FDTD, Perfect Electric and Magnetic Wall Boundary Conditions, Interface Conditions

Module IV

Finite Element Method: Basic Steps in Finite Element Analysis, Discretization or Meshing of the Geometry, Derivation of the Element Matrix, Assembly of Element Matrices, Solution of System Matrix, Post-processing, FEM Analysis in One-dimension, Treatment of Boundary and Interface Conditions, Accuracy and Numerical Dispersion, FEM Analysis in Two-dimension, Element Matrix for Rectangular Elements, Element Matrix for Triangular Elements, Assembly of Element

Matrices and System Equations, Capacitance of a Parallel Plate Capacitor, Cut-off Frequency of Modes in a Rectangular Waveguide, FEM Analysis of Open Boundary Problems

Text books:

1. Matthew N. O. Sadiku, *Computational Electromagnetics with MATLAB*, CRC press, 4/e, (2019) ISBN 978113855815-1.
2. Balanis.C.A, *Advanced Engineering Electromagnetics*, Wiley Publications, 3/e (2024), ISBN-10: 0471621943

References:

3. Hristos T A, *Numerical and Analytical Methods in Electromagnetics*, MDPI, (2021), ISBN 978303650064-5
4. David B. Davidson, *Computational Electromagnetics for RF and Microwave Engineering*, Cambridge university press,2/e (2010), ISBN 9780521518918
5. Ramesh Garg, *Analytical and Computational Methods in Electromagnetics*, Artech House, (2008), ISBN-9781596933859
6. Allen Teflove, Susan C Hagness, *Computational Electrodynamics: The Finite Difference Time Domain Method*., Artech House publications, 3/e, (2005), ISBN 9781580538329

23-203-0705 DEVICE MODELLING

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to:

1. Understand the basic operating principles of semiconductor devices.
2. Illustrate how circuit models have been derived from these principles.
3. Understand the secondary effects in semiconductor devices.
4. Analyse the different complex models like Polysilicon emitter transistor, heterojunction transistors, SOI MOSFET, Buried channel MOSFET.
5. Compare advanced transistor structures for optimizing high frequency and high performance analog/RF applications.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3											1	3	
CO 2	3											1	3	2
CO 3	3											1	2	
CO 4	3	2	2									1	2	2
CO 5	3											1	2	1

1-Slightly; 2-Moderately; 3-Substantially

Module-I

Operation of BJT at high frequencies-Charge control model, small signal equivalent circuit, design of high frequency transistors. Second order effects in BJT-non uniform doping in base, variation of β with collector current, high injection in collector, heavy doping effects in emitter, emitter crowding in Bipolar transistors. Nonconventional BJTs-Polysilicon emitter transistor, heterojunction bipolar transistor (HBT)

Module-II

Metal semiconductor junction-Energy band diagram, Current-Voltage characteristics of MS junction, Ohmic contacts. Junction field effect transistor-basic JFET structure, principle of operation, IV characteristics of JFETs, Small signal parameters of JFETs. MESFETS-structure, heterojunction FETs

Module-III

MOS diode- operation of MOS diode, C-V characteristics of MOS diode. The MOSFET-threshold voltage of MOSFET, Above-threshold I-V characteristics of MOSFETs, Process flow for a self-aligned nMOSFET

Module-IV

Effects of gate and drain voltage on carrier mobility in inversion layer-Channel length modulation, MOSFET breakdown and punch through, Subthreshold current-MOSFET scaling, Nonuniform doping in channel, Threshold voltage of short channel MOSFETs, Small signal analysis, Other MOSFET configurations-SOI MOSFET, Buried channel MOSFET

Text books:

1. Nandita Das Gupta, Amitava Das Gupta-*Semiconductor devices Modelling and Technology*, PHI (2009) ISBN 978120323988
2. S M Sze, M K Lee, *Semiconductor Devices –Physics and Technology*, Wiley Publications, 3/e (2010), ISBN 978047053794-7

References:

3. Y. Tsividis and Colin McAndrew, *The MOS Transistor*, 3/e (2013), Oxford University Press, ISBN 9780198097372.
4. Narain Arora, *MOSFET modeling for VLSI simulation: Theory and Practice*, World Scientific, (2007), ISBN 9789812568625.
5. Yuan Taur and Tak H Ning, *Fundamentals of Modern VLSI Devices*, Cambridge University Press,2/e, (2013), ISBN 9781107635715.
6. C. C. Hu, *Modern Semiconductor Devices for Integrated Circuits*, Prentice Hall, (2010), ISBN 978013608526

23-203-0706 ADAPTIVE SIGNAL PROCESSING

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to:

1. Understand the concepts of open loop and closed loop adaptation systems and describe properties of quadratic performance surfaces.
2. Understand basics of adaptive algorithms like LMS, RLS.
3. Model communication channels using adaptive FIR filter identification.
4. Evaluate adaptive beamforming configurations for interference cancellation.
5. Assess tradeoffs in performance and complexity for RLS and LMS.
6. Recommend adaptive algorithm/structure for modeling and cancellation applications.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	1	1									1	3	
CO 2	3	1	1	3								1	2	2
CO 3	3	1	1	3								1	2	2
CO 4	3	3	2									1	2	2
CO 5	3	3	2		1							1	3	
CO 6	3	3	2									1	2	

1-Slightly; 2-Moderately; 3-Substantially

Module I

Adaptive Systems – Definition & Characteristics – Properties - Open loop and closed loop adaptation –Example of adaptive system –Adaptive linear combiner – Input signal and Weight vectors – Desired response and Error – Performance Function – Gradient - Minimum mean square error – Example of performance surface - Alternative expressions of the Gradient – De-correlation of error and input components.

Module II

Properties of Quadratic performance surface – Normal form of input correlation matrix – Eigen values and vectors - Geometrical significance - Searching the performance surface – Methods – Gradient search methods – Stability and rate of convergence – learning curve – Newton's Method – Steepest Descent Method – Comparison of learning curves –Gradient estimation and its effect on adaptation – Performance penalty – Variance of gradient estimate – Excess Mean Square Error and Time constants – Mis-adjustment.

Module III

Adaptive Algorithms - The LMS Algorithm – Derivation- Convergence – Learning curve – Noise –Misadjustment – Performance - LMS/ Newton Algorithm – Properties –Sequential regression algorithm – Adaptive recursive filter – Random search algorithms – RLS Algorithm – The matrix inversion Lemma – Convergence.

Module IV

Adaptive modeling and system identification – Multipath communication channel –FIR digital filter synthesis –Introduction to adaptive arrays and beamforming – Sidelobe cancellation – Beamforming with a pilot signal –spatial configurations – Adaptive algorithms.

Text books:

1. Bernard Widrow and Samuel D. Stearns, *Adaptive Signal Processing*, Pearson Education, (2016) ISBN:9788131705322.

References:

1. Simon Haykin, *Adaptive Filter Theory*, Pearson Education, 5/e (2013), ISBN 9780132671453
2. B. Farhang-Boroujeny, *Adaptive Filters – Theory and Applications*, John Wiley and Sons, (1998), ISBN:978-0-471-98337-8
3. Ali H Sayed, *Fundamentals of Adaptive Filtering*, John Wiley -IEEE, 1/e, (2003), ISBN 9780471461265

23-203-0707 DIGITAL INTEGRATED CIRCUIT DESIGN

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to:

1. Analyze properties of static and dynamic CMOS logic styles. Design efficient combinational logic gates using ratioed pass transistor, pseudo-NMOS logics and domino logic. Evaluate speed, power, noise immunity and robustness.
2. Analyze latches and flip-flops based on static and dynamic techniques. Evaluate timing parameters, power consumption and noise susceptibility.
3. Analyze and design efficient ripple carry, carry look-ahead, bypass and conditional sum adder architectures. Evaluate delay, power and area trade-offs.
4. Design array, tree and Wallace tree multipliers. Evaluate performance metrics like delay, regularity and power.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	3	3	1	1							1	2	2
CO 2	3	3	3	1	1							1	2	2
CO 3	3	3	2	1	1							1	2	2
CO 4	3	3		1	1							1	2	2

1-Slightly; 2-Moderately; 3-Substantially

Module I

Designing combinational logic gates in CMOS (Static)

Introduction - Static CMOS Design - Complementary CMOS, Static properties, Design techniques for larger fan in, design techniques to reduce switching activity, Ratioed Logic, Pseudo NMOS inverter, Building better loads, Pass-Transistor Logic -Voltage swing-VTC, Differential Pass Transistor Logic, Robust and efficient Pass transistor design-Level Restoration

Module II

Designing combinational logic gates in CMOS (Dynamic)

Dynamic CMOS Design - Dynamic Logic: Basic Principles, Speed and Power Dissipation of Dynamic Logic, Signal integrity issues in Dynamic Logic-Charge leakage, Charge sharing, Capacitive coupling, Cascading dynamic gates, Domino Logic, NP CMOS

Module III

Designing sequential logic circuits

Static Latches and Registers - The Bistability Principle - Multiplexer-Based Latches - Master-Slave Edge-Triggered Register Timing properties of Multiplexer based Master Slave register- - Static SR Flip-Flops - Dynamic Latches and Registers - Dynamic Transmission-Gate Edge-triggered Registers - C^2MOS register, Dual Edge register, True Single-Phase Clocked Register (TSPCR)

Module IV

Designing arithmetic building blocks

The Adder -Propagation delay of ripple carry adder, Full adder design considerations, Static adder, mirror adder, transmission gate based adder, Manchester carry chain adder, Binary adder Logic Design Considerations Carry bypass adder, linear carry select adder, square root carry select adder, carry look ahead adder - The Multiplier - Partial-Product Generation - Partial Product Accumulation - Array multiplier, carry save multiplier, tree multiplier, Wallace tree multiplier. - The Shifter - Barrel Shifter - Logarithmic Shifter

Text books:

1. Jan M. Rabaey, A. Chandrakasan, B. Nikolic, *Digital Integrated Circuits- A Design Perspective*, Pearson education, 2/e, (2016), ISBN 9789332573925

References:

2. Hubert Kaeslin, ETH Zürich *Digital Integrated Circuit Design - From VLSI Architectures to CMOS Fabrication,* Cambridge University press, 1/e, (2008), ISBN:9780521882675
3. John F Wakerly, *Digital Design – Principles and Practices*, Pearson education, 4/e,(2008), ISBN 9789332508125
4. Neil H E Weste, David Money Harris, *CMOS VLSI Design: A Circuits and Systems perspective*, 4/e (2015), ISBN 9789332542884

23-203-0708 DEEP LEARNING FOR COMPUTER VISION

Course Outcomes

On successful completion of teaching-learning and valuation activities, a student would be able to:

1. Understand the basics of computer vision principles.
2. Understand deep learning principles, including neural network architectures, optimization algorithms, and regularization techniques.
3. Apply various CNN architectures for computer vision tasks, such as image classification, object detection, and image segmentation.
4. Apply transfer learning techniques to leverage pre-trained CNN models for computer vision tasks.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	1	1	1								1	3	
CO 2	3	1	1	2								1	3	1
CO 3	3	3	3	2								1	2	2
CO 4	3	3	3	2								1	2	2

1-Slightly; 2-Moderately; 3-Substantially

Module 1

Introduction to computer vision: Image Formation and Representation-Components of a vision system, Radiometry-Light in space and surface, Sources-Shadows and shading, Geometry of multiple views

Module 2

Artificial Neural Networks: Multilayer perceptron, Feed forward Neural network and back propagation, Gradient decent and variants, Regularization and training

Module 3

Deep Learning Convolutional Neural Network, Convolution filters, feature detectors, padding, strided convolution, pooling, Fine tuning in CNN, Image classification and object detection,

Module 4

Recent Advances: Transformers: Attention, Transformer processing, Multimodal transformers, Generative Adversarial Network- Autoencoders, Graph Neural Networks

Text books:

1. Richard Zaleski, *Computer Vision: Algorithms and Applications,* Springer, 2/e (2021).
2. Christopher Bishop, Hough Bishop, *Deep Learning Foundations and Concepts*, Springer, (2023).
3. Bernd Jahne and Horst Hau Becker, *Computer vision and Applications*, Academic press, (2007), ISBN 8131208451.

23-203-0709 5G COMMUNICATION TECHNIQUES

Course Outcomes

On successful completion of teaching-learning and valuation activities, a student would be able:

1. To analyze impact of frequency allocation, signal propagation, modulation, coding, multiplexing, multiple access, antennas, diversity etc. on wireless communication
2. To compare cellular technologies and identify motivation and challenges related to their evolution.
3. To analyze 5G features and study related clauses in standards.
4. To Configure key parameters of the 5G system to meet given requirements.
5. To explain 5G enhancements and potential 6G features

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	3	2							1		2	3	1
CO 2	3	1	1							1		2	2	
CO 3	3	3	3							1		2	2	
CO 4	3	1	1							1		2	2	
CO 5	3	1	1							1		2	2	

1-Slightly; 2-Moderately; 3-Substantially

Module I

5G: Evolution and Overview, principles underlying different generations. Engineering requirements and application scenarios for 5G. Cellular concept and architecture, channel re-use; 5G overview: Key features, evolution from 1G to 5G, Migration challenges of 5G; 5G use cases, requirements and performance metrics: IMT 2020, eMBB, URLLC, mMTC; Spectrum for 5G, frequency ranges and bands, spectrum sharing, NR-U.

Module II

5G Standards, Architecture and Protocol Stacks: 5G standards overview; 5G architecture: 5G RAN architecture, 5GC architecture; NFV, Network slicing, QoS, Policy control, 5G security; Control plane protocol stack: NAS, RRC; User plane stack: SDAP, PDCP, RLC, MAC, PHY; Initial access; Paging; Mobility.

Module III

5G PHY: Numerology; symbol, slot and frame structure; OFDM waveform; Bandwidth and sampling rate; Downlink control aspects: control region, search space, DCI formats; Downlink data aspects: modulation and coding, resource allocation in time and frequency, HARQ operation, Reference Signals; Uplink control aspects, PUCCH formats; Uplink data aspects: resource allocation, modulation and coding options, Reference signals, Power control; Link budget calculations; Peak throughput calculations; MIMO; Beam management, NOMA.

Module IV

5G Features: 5G Advanced: mmWave, massive MIMO-characteristics & benefits, signal and channel models, Differences between point-to-point MIMO and multiuser MIMO URLLC, MTC, D2D/V2X, NTN, Edge computing, and 5G power saving features; future standards: 6G and beyond.

Text book:

1. Juan Montojo, Peter Gaal, Haris Zisimopoulos and Wanshi Chen, *"Fundamentals of 5G Communications: Connectivity for Enhanced Mobile Broadband and Beyond"*, McGraw Hill, 1/e, (2021).
2. "3GPP TS 38.300", Version 16.12.0, 3GPP, (2023).

References:

3. Stefan Rommer, Peter Hedman, Magnus Olsson, Lars Frid, Shabnam Sultana and Catherine Mulligan, *"5G Core Networks: Powering Digitalization"*, Academic Press, 1/e, (2019).
4. Erik Dahlman, Stefan Parkvall and Johan Skold, *"5G NR: The Next Generation Wireless Access Technology"*, Academic Press, 2/e, (2020).
5. Stefania Sesia, Issam Toufik, Matthew Baker, *"LTE – The UMTS Long Term Evolution: From Theory to Practice",* Wiley, 2/e, (2011).

23-203-0710 RF CIRCUIT DESIGN

Course Objectives:
To get an idea about the various techniques used in RF design

Course Outcomes:
On successful completion of teaching-learning and valuation activities, a student would be able:

1. Understand high frequency behavior of passive RF components and equivalent circuit models for RF transistors.
2. Analyze RF circuits using s-parameters and design small signal narrowband RF amplifier as per specifications.
3. Compute intermodulation distortion and dynamic range for a power amplifier.
4. Evaluate stability and gain bandwidth tradeoffs in wideband amplifier design.
5. Analyze phase noise and architectures of RF oscillators and synthesizers.
6. Assess trends in software defined radio and DSP for radio communications.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	1	1							1		1	3	
CO 2	3	2	3	2						1		1	2	2
CO 3	3	1	1							1		1	2	2
CO 4	3	3	1							1		1	3	
CO 5	3	3	3	2						1		1	2	
CO 6	3	3	3	2						1		1	2	

1-Slightly; 2-Moderately; 3-Substantially

Module I
Passive Components for RF: Behavior at High Frequencies: Wire, Resistors, Capacitors, Inductors, Toroids and their winding, Impedance Transformation, Coupling of Resonant Circuits.
Active RF Components: RF diodes, RF transistors; The Transistor at Radio Frequencies: Equivalent Circuit, Y-Parameters, S-Parameters, and other relevant two-port parameters, RF Transistor Data Sheets.
Computer-Aided Design and Analysis, Interconnection of networks Analysis techniques, Optimization Use of SPICE (Practical assignments using HSPICE is recommended)

Module II
Microwave Printed Circuits & Microwave Solid State Devices: Bipolar Microwave Transistor, MESFET, MODFET/HEMT, Microwave IC's, Microwave Diodes, and MODAMPs, Strip lines, Micro strips, Printed Microwave Components, Surface Acoustic Wave device.
Amplifiers: High Frequency Amplifier Design, Small Signal RF Amplifier Design-Biasing, Designs using Y and S Parameters, Broadband Amplifiers, Single Stage, Multistage designs. Gain and stability analysis using S parameters. Wide Bandwidth Design. Fundamental limitations on matching Transmission line transformers. Use of feedback in RF amplifier design. Design for specified gain, bandwidth and SWR.

Module III
RF Power Amplifiers: RF Power Transistor Characteristics, Biasing, Design, Matching to Coaxial Feed lines, Large Signal Amplifiers, Amplifier classes and efficiency, Dynamic range, Intermodulation distortion, Third-order intercept, Design of large signal linear amplifiers. Design of large-signal class-C amplifiers, Design of switch-mode amplifiers. Power combiners, Directional Couplers, Hybrids.

Module IV

Oscillators and Mixers: Basic oscillator model, Oscillator, Synthesizer, Phase-locked loop, Phase noise, PLL structures & Architectures. Direct Digital Synthesis, Mixer-basic concepts, single ended, single balance and double balanced mixers. Software Radio and DSP in Radio Communication.

Text book:

1. M. N. Radmanesh, *RF and Microwave Electronics illustrated*, Pearson Education, (2015) ISBN 9788177584011.
2. Reinhold Ludwig, Pavel Bretchko, *RF Circuit Design: Theory and Practice*, PHI., 2/e (2011) ISBN 9788131762189.

References:

3. Richard Chi-Hsi Li, *RF Circuit Design 2e:102 (Information and Communication Technology Series),* Wiley, 2/e, (2012), ISBN 9781118128497
4. Ali Behagi, *RF and Microwave Circuit Design: Updated and Revised with 100 Keysight (ADS)*, Techno search publishers (2017).
5. Jose Carlos Pedro, David E Root, Jianjun Xu, Luis Cotimos Nunes, *Nonlinear Circuit Simulation and Modeling: Fundamentals for Microwave Design -The Cambridge RF and Microwave Series,* Cambridge University press, (2018) ISBN 9781107140592.

23-203-0711 DESIGNING WITH ARM MICROCONTROLLER

Course Outcomes:

After successful completion of the course student will be able to:

1. Describe the key features and architecture of ARM processors and microcontrollers for embedded systems applications
2. Interface various analog and digital sensors, actuators, displays, motors and other devices to an ARM microcontroller and write drivers to operate them
3. Develop embedded software applications leveraging ARM microcontroller capabilities such as GPIO, timers, ADCs, DACs, UART serial communication, interrupt handling, and power management
4. Apply wireless communication technologies like Bluetooth and WiFi for connected embedded systems with ARM microcontrollers
5. Employ debugging and emulation techniques to test and validate operation of software on ARM architecture using appropriate development tools
6. Evaluate ARM processor and microcontroller design tradeoffs and select suitable ARM chip variants for proposed embedded system applications

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	2	3	1								2	3	
CO 2	3	2	3	1								2	2	2
CO 3	3	2	3	1								2	2	2
CO 4	3	2	3	1								2	2	
CO 5	3	2	3	1								2	2	
CO 6	3	2	3	1	3							2	2	

1-Slightly; 2-Moderately; 3-Substantially

MODULE 1

Introduction to embedded system and ARM Processor. ARM related Companies and its opportunities. ARM processor family. Application of ARM Processor. Compiler. Emulation and Debugging. Difference between RISC & CISC.
ARM microcontroller. Features, Block diagram, Pin diagram. Architectural overview. On-chip flash program memory. On-chip static RAM. Comparison between ARM & RISC V architecture.

MODULE 2

Instruction set architecture of ARM microcontroller, and assembly language programming
D/A and A/D converter, sensors, actuators and their interfacing
GPIO Configuration, Driving De-initialization, Interfacing IO devices and its type – LEDs, Switches, Buzzer, Seven Segment Display, LCD (4 bit, 8-bit Mode), Keypad (4*4), DC Motor, Stepper Motor, Servo motor, Relay.

MODULE 3

NVIC Controller, Enabling Interrupt, Interrupt Priority Levels, UART Initialization, UART communication in polling Mode & in Interrupt Mode. Wireless Technologies- Bluetooth, Wi-Fi, RF.

MODULE 4

Timers Basics, General Purpose Timer, SysTick Timer, ADC & DAC Basics, Initialization, DAC Peripherals & Modules. Analog Sensors and its Types (Ultrasonic Sensor, Temperature, Humidity, Soil Moisture Sensor, PIR sensor)

Text books:

1.F. Vahid and T. Givargis, *"Embedded System Design: A Unified Hardware/Software Introduction",* Wiley, student edition, (2006), ISBN 9788126508372.

2. A.N. Sloss, D. Symes and C. Wright, *"ARM System Developer's Guide: Design and Optimizing System Software",* Morgan Kaufman Publishers, (2004), ISBN 9781558608740

3. W. Wolf, *"Computers as Components: Principles of Embedded Computing System Design",* Morgan Kaufman Publishers, 2/e, (2008), ISBN 9780123743978.

23-203-0712 ELECTRONIC PRODUCT DESIGN

Course Objectives:

To design an electronic product with industrial standards.

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able:

1. To analyze the products existing in the market,
2. To convert a concept to an electronic product
3. To solve various practical issues like noises, thermal management and EMI
4. To understand the Industrial Design Process, IP Rights modelling of electronic components and PCB design

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	3	3	1	1							1	2	
CO 2	3	1	1	1	1							1	2	2
CO 3	3	3	1	1	1							1	2	
CO 4	3	1	1	1	1							1	1	3

1-Slightly; 2-Moderately; 3-Substantially

Module I

Overview: - From Requirement to Product: Engineering design as real life problem solving- Requirement analysis of Electronic products- Formulation of product requirement specifications and target specifications.

The design process: Product conceptualization- Product architecture- Product synthesis- Portable Electronic Design Factors- Computer Aided Design. Product Life Cycle. Various dimensions of Electronic Product Design- Industrial design and Engineering design- Aesthetics and Ergonomics- Inputs, control and display interface.

Module II

Electronic interconnection and Packaging of components, Integrated circuits, Printed circuits and Functional products- Cables and connectors- Design Documentation, Engineering Documentation and Test Documentation Component Specification/ Bill of materials. Enclosure sizing, requirement of enclosure and standards of enclosures. Noise and thermal management: Noise- Types of Noise-Noise coupling mechanisms in Electronic Circuits-EMI/EMC, EMI standards and regulations, Grounding, cabling, Shielding, Guarding

Module III

Thermal Considerations in Electronic Product Design: Heat generation and modes of heat transfer in Electronic Products- Selection/Design of Heat Sinks- Factors affecting the design of heat sinks and its cooling Effectiveness-Assembly of components on heat sinks- Electrical analogue of thermal circuits- Enclosure design of Electronic Equipments and thermal considerations- Design guidelines for Ventilations- Forced cooling- Heat pipes for electronic cooling applications.

Module IV

PCB design: requirements in PCB Design- PCB Design elements- PCB design process- advantages of PCBs. Design rules for analog, digital, high-frequency, power-electronic and MW PCBs-PCB design guidelines for EM compatibility.

Introduction to SPICE simulation of circuits- Circuit description- Modelling of active and passive circuit elements - DC, AC, Transient and Parametric circuit analysis.

Module V (Tutorial Only-No questions from this module for End Semester Examination)

Electronic Design Automation Tools: Introduction to PC based Electronic Design Automation Tools: Schematic Capture, Circuit Simulation, Layout Design etc. features like EMI analysis, Thermal analysis, 3d visualization etc. of such packages with reference to EDA tools such as Orcad, EDWIN XP etc.

Assignment: Design and simulation of an electronic product following the above syllabus using EDA tools.

Text books:

1. R.G.Kaduskar, V.B Baru, *Electronic Product Design*, Wiley India, 2/e, (2011), ISBN 978-8126533169.
2. Karl T. Ulrich & Steven D. Eppinger, *Product Design and Development*, Tata McGraw Hill, 7/e, (2020), ISBN 978-9390113231
3. Ralph Remsburg*, Thermal Design of Electronic Equipment,* CRC Press, ISBN 0-8493-0082-7.
4. Mohammed H. Rasheed, *Spice for circuits & Electronics using Pspice*, Pearson Education, 2/e, (1994), ISBN 978-0131246522

References:

5. V. Prasad Kodali, *Engineering Electromagnetic Compatibility-Principles, Measurements, and Technologies*, S. Chand & Company Ltd, (2000), ISBN 978-8121919852
6. Walter C. Bosshart, *Printed Circuit Boards- Design and Technology*, Tata McGraw Hill, 1988, ISBN 978-0074515495
7. Kevin Otto, Kristin Wood, *Product Design- Techniques in Reverse Engineering and New Product Development*, Pearson Education, (2004), ISBN 978-0130212719
8. Richard Stillwell, *Electronic Product Design for Automated Manufacturing*, CRC Press, (1988), ISBN 978-0824779375
9. Bert Haskell, *Portable Electronics Product Design and Development*, McGraw Hill, (2004), ISBN 978-0071634021

23-203-0713 INTELLECTUAL PROPERTY RIGHTS

Course Outcomes

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

1. Understand the basic concepts of IPR
2. Get exposure to various aspects of IPR
3. Get knowledge of Registration of IPR and its enforcement

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3					1		2		2	2	1	3	
CO 2	3					2		2		3	2	1	2	
CO 3	3					3		2	1	3	2	1	2	

1-Slightly; 2-Moderately; 3-Substantially

Module I

Basic Concept of IPR: Basic Concepts of Intellectual Property- Introduction to intellectual property rights, laws and its Scope, Trade Related Aspects of Intellectual Property Rights.

Introduction to patent law and condition for patentability, Procedure for obtaining patents, Rights of a patentee, Patent infringements, Bio-technology patents and patents on computer programs, Patents from an international perspective.

Module II

Trademark & Geological Indications - Trademark and 'geographical Indications: Statutory authorities and registration procedure, Rights conferred by registration, Licensing, assignment and transfer of trademark rights, Trademark infringement, Geographical Indication of Goods & Appellations of Origin.

Module III

Copyright: Copyright Registration procedure and copyright authorities, Assignment and transfer of copyright, copyright infringement and exceptions to infringement, Software copyright

Module IV

Law on Industrial Designs -Introduction to the law on Industrial Designs, Registration and piracy, International perspective, Introduction to the law on semiconductor layout design, Registration, commercial exploitation and infringement.

Text books:

1. Vinod V Sople, *Managing Intellectual Property- The Strategic Imperative*, PHI, 5/e (2016), ISBN 9788120352650
2. Krishna Kumar, *Cyber law, intellectual property and e-commerce security*, Dominant Publication and distribution, (2011), ISBN 8187336897

References:

3. Craig Fellenstein, Rachel Ralson, *Inventors Guide to Trademarks and Patents*, Prentice Hall, 1/e, (2011), ISBN 9780132597562
4. David Bainbridge, *Intellectual Property,* Longman, 8/e, (2010), ISBN 9781408229286

23-203-0714 ENTREPRENEURSHIP DEVELOPMENT

Course Outcomes

On completion of this course the student will be able to

1. Develop awareness about the importance of entrepreneurship opportunities available in the society
2. Get acquainted with the challenges faced by the entrepreneur
3. Become aware of various stress management techniques
4. Conduct a break-even analysis of a project

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	**2**	**2**	**2**									**1**	**1**	
CO 2	**2**	**2**	**2**	**2**				**1**				**1**	**1**	
CO3	**2**	**2**	**2**	**2**				**1**				**1**		
CO4	**2**	**2**	**2**	**2**				**1**				**1**	**1**	**1**

1-Slightly; 2-Moderately; 3-Substantially

Exercises:

1. To study the types of entrepreneurs and the factors affecting entrepreneurial growth
2. To make an assessment of the major motives influencing an entrepreneur
3. To make an overview of the various stress management techniques
4. How to identify and select a good business opportunity?
5. Preparation of a techno economic feasibility report for a given project
6. Preparation of a preliminary project report for a given project
7. To identify the various sources of finance and management capital
8. Carry out the costing and break-even analysis of a proposed project
9. Preparation of PERT/CPM chart for the various activities involved in a project
10. To make a study of the various causes and consequences of sickness in a small business and identify the corrective measures.

Text books:

1.Roy Rajeev, *Entrepreneurship,* 2/e, Oxford latest edition, (2011)
2.E Gordan, K Natarajan, *Entrepreneurship Development*, 4/e, Himalaya (2007)
3. Bhargava S, *Transformational Leadership: Value based management for Indian Organisations* (2003) Response Sage

References:

1.Coulter, *Entrepreneurship in Action*, 2/e, PHI, (2008)
2.P C Jain, *Handbook for New Entrepreneur*, Oxford University press (2003)
3.S S Khanka, *Entrepreneurial Development*, 5/e, S Chand and Co, (2013)

Note: There will be only continuous evaluation for the course. The evaluation will be based on the performance of the student in the exercises given. A minimum of 50% marks is required for a pass.

23-203-0715 SEMINAR

Course Objectives:

To encourage and motivate the students to read and collect recent and relevant information from their area of interest confined to the relevant discipline from technical publications including peer reviewed journals, conferences, books, project reports, etc., prepare a report based on a central theme and present it before a peer audience

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able

1. To Identify and familiarize with some of the good publications and journals in their field of study.
2. To Acquaint oneself with preparation of independent reports, name them based on a central theme and write abstracts, main body, conclusions and reference identifying their intended meaning and style.
3. To Understand effective use of tools of presentation, generate confidence in presenting a report before an audience and improve their skills in the same.
4. To Develop skills like time management, leadership quality and rapport with an audience.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	1							1	3		3	2	
CO 2	3	1							1	3		3	2	
CO 3	2	1							1	3		3	2	3
CO 4	2	1							1	3		3	2	1

1-Slightly; 2-Moderately; 3-Substantially

Students shall individually prepare and submit a seminar report on a topic of current relevance related to the field of Electronics & Communication Engineering. The reference shall include standard journals, conference proceedings, reputed magazines and textbooks, technical reports and URLs. The references shall be incorporated in the report following IEEE standards reflecting the state-of-the-art in the topic selected. Each student shall present a seminar for about 30 minutes duration on the selected topic. The report and presentation shall be evaluated by a team of internal experts comprising of 3 teachers based on style of presentation, technical content, adequacy of references, depth of knowledge and overall quality of the seminar report.

23-203-0716 PROJECT PHASE I

Course Outcomes:

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

1. Conduct a comprehensive literature survey to identify and analyze a specific problem statement in Electronics Engineering.
2. Formulate a well-structured project proposal by synthesizing literature insights and engaging with industry experts and academic mentors.
3. Develop a detailed execution plan for Phase II, including resource allocation, timeline, and risk management strategies.
4. Demonstrate technical communication skills through a properly formatted thesis document and professional PowerPoint presentations.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	2	1	3	1	1			3	3	2	3	1	
CO 2	2	3	2	2		3	3	3	2	3	3	3	2	
CO 3	1	1		2	3			3	3	3	3	2	2	1
CO 4	3	3		1	2	3	3	3	2	3		3	2	2

1-Slightly; 2-Moderately; 3-Substantially

This course aims to equip undergraduate students in Electronics Engineering with the essential skills and knowledge required to successfully navigate through the initial phases of a project. Students will learn to conduct a comprehensive literature survey, identify and focus on a specific problem, formulate a project proposal, develop an execution plan for Phase II, and enhance their technical communication skills through thesis preparation and presentation techniques.

Topics to be Covered

- Introduction to Literature Survey and Problem Identification: Understanding the significance of literature survey in research, Techniques for conducting a thorough literature review, identifying relevant areas of study within Electronics Engineering, and Narrowing down to a specific problem statement.
- Formulating a Project Proposal: Guidelines for structuring a project proposal, the importance of consultation with industry experts and academic mentors, incorporating insights from the literature survey into the proposal, Developing a clear and concise problem statement and objectives
- Project Execution Planning: Principles of project management and planning, developing a detailed execution plan for Phase II of the project, identifying resources, timeline, and milestones.
- Enhancing Presentation Skills: Understanding the elements of effective presentations, Techniques for engaging and communicating technical information, Hands-on practice sessions on preparing and delivering technical presentations, and Peer feedback and improvement strategies.
- Technical Communication: Thesis Preparation- Structure and format of a thesis document, Guidelines for writing thesis chapters- introduction, literature review, methodology, results, discussion, conclusion, Typesetting using Word or LaTeX for professional thesis formatting. Prepare PPTs for technical presentation.

Assessment:

Guidelines for evaluation:		Marks
1	Attendance and Regularity	10
2	Literature Survey and Problem Identification	10
3	Project Proposal	10
4	Project Execution Plan	10
5	Thesis and Presentation Skills Assessment	10
	Total	50

Note: Points (1)-(3) are to be evaluated by the respective project guides and project coordinator based on continuous evaluation. (4)-(5) to be evaluated by the final evaluation team comprising 3 internal Examiners.

References:

1. Jesson, J., Matheson, L., and Lacey, F. M., Doing Your Literature Review: Traditional and Systematic Techniques, Sage Publications Ltd, (2011).
2. Machi, L. A., and McEvoy, B. T., The Literature Review: Six Steps to Success, Corwin Press, (2016).
3. Friedland, A., and Folt, C., Writing Successful Science Proposals, Yale University Press, (2009).
4. Duarte, N., Slide:ology: The Art and Science of Creating Great Presentations, O'Reilly Media, (2008).
5. Joyner, R. L., Rouse, W. A., and Glatthorn, A. A., Writing the Winning Thesis or Dissertation: A Step-by-Step Guide, Corwin Press, (2013).

23-203-0717 INTERNSHIP-III

Course Outcomes:
On completion of this course the student will be able to:

1. Understand the real time technical/managerial skills required and relevant to the subject area of internship
2. Initiate a habit of proper daily diary writing with adequacy and quality of information recorded, drawing and sketches and data, thought process and the proper organisation of the information gained during the internship.
3. Conceive the pros and cons of working in a real time industrial environment and the wonderful results which could evolve through team-work.
4. Present and defend self-prepared and corrected internship report (with the help of internship guide/industry mentors) of a self-created work to a peer audience.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	1					1	2	3		2		3	2	
CO 2		1	1			3	1	3	2	3		3	1	
CO 3	2	2	1		3	1	2	3	1	1	2	2	2	
CO 4						2			3	2	2	1	2	1

1-Slightly; 2-Moderately; 3-Substantially

Internship Guidelines

- An internship plan has to be prepared by the interns incorporating the job description/internship duties, name of the project, if any and internship schedule and expected learning outcomes in consultation with industry supervisor/mentor and institute faculty.
- A detailed training report in the prescribed format shall be submitted at the end of the internship.
- Training Certificate from the industry for the prescribed period shall be submitted at the end of the internship.
- The work shall be reviewed and evaluated periodically.
- Orientation of interns, resource requirement of interns, monitoring of interns progress on a daily basis shall be carried out by the industry offering internship in addition to ensuring safety and welfare of the interns.

A committee consisting of the Internship Coordinator (nominated by the Head of the Department/Division), faculty mentor, and at least one senior faculty member must be assigned to evaluate the work.
Guidelines for evaluation:

Regularity and progress of work	10
Work knowledge and Involvement	10
Semester End presentation and oral examination	10
Level of completion of internship	10
Internship Report – Presentation style and content	10
Total	50 Marks

SEMESTER VIII
23-203-0801 COMPUTER COMMUNICATION AND NETWORKING

Course Objectives

On successful completion of teaching-learning and valuation activities, a student would be able to:

1. Understand the layered TCP/IP and OSI reference models for modular network design.
2. Analyze data flow and error control mechanisms in data link layer network protocols.
3. Evaluate routing algorithms to select the optimal path based on metrics like latency, number of hops.
4. Evaluate security protocols like IPSec, SSL based on encryption methods, interoperability, computational overhead, etc.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	1				1				1	1	1	3	
CO 2	3	1								1		1	2	
CO 3	2	1					1	1		1		1	2	
CO 4	2	1							1	1		1	2	2

1-Slightly; 2-Moderately; 3-Substantially

Module I

Introduction to Computer Networks: The Internet, Protocols and Standards. Network models- the OSI reference model, the TCP/IP reference model. Addressing. Packet switching, circuit switching. Network Topologies.

The physical layer: Transmission media –guided and wireless.

Module II

The data link layer: Forward Error Correction – CRC. Framing, flow and error control. Data link protocols –noiseless stop and wait, ARQ, HDLC. Multiple access- random access, ALOHA, CSMA, controlled access - reservation, polling, token rings. WLAN - IEEE 802.11. Devices – hubs, bridges, switches, routers, modems, gateways.

Module III

Network layer: Packet Switching Networks. Routing algorithms - routing tables, shortest path algorithm, link state, distance vector routing. IPv4 protocol: IPv4 addresses, transition to IPv6, Network address translation (NAT).

Module IV

Transport Layer: User Datagram Protocol (UDP), Transmission Control Protocol (TCP). Application Layer: WWW and HTTP, Domain Name System (DNS).

Network Security: Symmetric and asymmetric encryption, keys- cipher. RSA. Introduction to DES and AES, Firewall. SSL.

Text books:

1. Behrouz A. Fourouzan*, Data Communications and Networking,* Tata McGraw Hill, 5/e, (2017), ISBN 9781259064753
2. Andrew S. Tanenbaum, *Computer Networks*, Pearson education/ PHI Ltd., 5/e, (2010), ISBN 9780132126953

References:

3. James F. Kurose and Keith W. Ross, *Computer Networking - A Top-Down Approach Featuring the Internet,* Pearson Education, 5/e, (2016), ISBN 9780133594140
4. Bertsekas and Gallagar, *Data Networks*, Pearson Education, 2/e, (2015), ISBN 9789332550476
5. Leon Garcia &Widjaja, *Communication Networks,* Tata McGraw Hill, 2/e, ISBN 9780070595019
6. F. Halsall, *Data Communication, Computer Networks and Open System*s, Addison Wesley, 1996
7. S. Keshav, *An Engineering Approach to Computer Networkin*g, Pearson education, 1/e, (2002) ISBN 9788131711453
8. William Stallings, *Wireless Communications & Networks,* Prentice Hall, 2/e, (2001), ISBN 9788132231561

23-203-0802 SYSTEMS ENGINEERING

Course Outcomes

On successful completion of teaching-learning and valuation activities, a student would be able to

1. Describe processes, methods, and practices of systems engineering.
2. Apply systems engineering practices and methods to relevant examples.
3. Develop requirements, architectures, specifications, verifications, and tests.
4. Analyze systems using systems engineering approaches to increase performance.
5. Recognize important systems engineering and systems thinking strategies and practices in examples and cases.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	1	3	1								1	3	
CO 2	3	2	3	2								1	3	2
CO 3	3	2	3	1								1	2	
CO 4	3	1	3	1								1	2	2
CO 5	3	1	3	1								1	2	

1-Slightly; 2-Moderately; 3-Substantially

Module I

Fundamentals of Systems Engineering, Discipline specific Engineering Standards: Systems Engineering: History and Examples, System Engineering as Profession, Power of System Engineering, Systems Engineering viewpoint, Perspectives, Domains, fields, approaches, activities and products, System Engineering Management(SEM), Program, /Project Life Cycle, Lifecycle Integration, Engineering standards

Module II

Complex System Structure: Building blocks, hierarchy, interfaces, environment, interactions, life cycle, evolutionary characteristics. Systems Engineering. method, Systems testing throughout development. Systems development Management: Work breakdown structure (WBS), Systems Engineering Management Plan (SEMP), Systems risk management, organizing for systems engineering. Need analysis – originating, operations, functional, and feasibility. Need validation, systems operations requirement System requirements development, performance requirements.

Module III

Engineering Concept Stage: Concept exploration, validating requirements. Concept definition – selection and validation, functional analysis and allocation. Systems architecture, system modeling languages, Model-Based Systems Engg (MBSE) Decision making, modeling for decisions. Simulation, Trade-off analysis. Engineering development Stage: Program risk reduction, prototype development for risk mitigation. Development testing, risk reduction. Revision of functional analysis and design, Overview of probability data analysis, Hypothesis testing.

Module IV

Engineering design Stage: Implementing system building blocks, component design. Design validation, Change management. Concepts of reliability, redundancy. Concepts of maintainability, availability, predictability, User interface design and GUI. Integration, testing and evaluation of Total system: Test planning and preparation, system integration. Developmental and operational test and evaluation. Engineering for production, transition from development to production, Production operations. Installation, maintenance and upgrading, Installation testing, In-service support, Upgrades and modernization.

Text books:

1. INCOSE, Systems *Engineering Handbook: A Guide for System Life Cycle Processes and Activities*, Wiley, 4/e, (2015), ISBN: 9781118999400.
2. Kossiakoff, A., Sweet, W.N., Seymour, S.J., and Biemer S.M, *Systems Engineering,* Wiley ,3/e, (2020), ISBN 9781119516668

References:

3. Dahai Liu, *Systems Engineering Design Principles and Models*, CRC Press, 1/e, (2015), ISBN 9781466506831
4. Subhash Chander, *Systems Engineering*, Satya Prakashan Publisher, (2017), ISBN 9789351921165

23-203-0803 NEURO-FUZZY SYSTEMS

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able:

1. To understand the basics of Neural Networks and essentials of Artificial Neural Network
2. To understand Fuzzy sets and Fuzzy Logic system components
3. To differentiate between Neuro – Fuzzy and Fuzzy – Neural Controllers

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	2		1	2			1				1	3	2
CO 2	3	1	1									1	2	1
CO 3	3									1		1	2	1

1-Slightly; 2-Moderately; 3-Substantially

Module I

Introduction to ANNs: Classical AI and Neural Networks, Human brain and the biological neuron, Artificial Neurons, Neural Networks and architectures, feed forward and feedback architectures, geometry of binary threshold neurons and their networks, Supervised and unsupervised learning, concepts of generalization and fault tolerance Supervised learning: Perceptrons and LMS, Back propagation Neural Networks, Fast variants of Back propagation.

Module II

Statistical pattern recognition perspective of ANNs: Bayes theorem, implementing classification decisions with the Bayes theorem, interpreting neuron signals as probabilities, Multilayered networks, error functions, posterior probabilities, error functions for classification problems, Support vector machines, RBFNNs, regularization theory, learning in RBFNNs, Image classification application, PNNs.

Module III

Recurrent Neural Networks: Dynamical systems, states, state vectors, state equations, attractors and stability, linear and non-linear dynamical systems, Lyupanov stability, Cohen Grossberg theorem, Attractor neural networks: Associative learning, associative memory, Hopfield memory, Simulated annealing and the Boltzmann Machine, BAM, ART principles, Self-Organizing Maps

Module IV

Fuzzy Logic- Introduction, Fuzzy Sets, Concept of Fuzzy Number, Operation of Fuzzy sets, Properties of Fuzzy Set, Fuzzy versus probability, Fuzzy relations and Fuzzy relation calculations – Fuzzy members – Indices of Fuzziness –Comparison of Fuzzy quantities – Methods of determination of membership functions. Fuzzy Rule systems and interpretability of Fuzzy Rule systems, Knowledge Processing with Fuzzy Logic, Fuzzy Linguistic variables, Linguistic Modifier, Fuzzy Implication Relations/ Compositional Rules.

Text books:

1. B.Yegnanarayana, *Artificial Neural Networks,* Prentice Hall of India,(2009), ISBN 9788120312531
2. S. Ramakrishnan, *Modern Fuzzy Control Systems and its applications*, Intechopen, (2017), ISBN 9789535133896

References:

3. Simon Haykin, *Neural Networks: A comprehensive foundation,* Pearson Education*,* 2/e*,*1997, ISBN 9780138958633
4. James A Freeman, David M Skapura, Neural Networks- Algorithms, Applications and Programming Techniques, Pearson, 1/e, 2012, ISBN 9788131708088
5. Timothy J Rose, *Fuzzy Logic with Engineering applications,* Wiley, 3/e, 2016, ISBN 9788126531264

23-203 -0804 MEMORY AND INTERCONNECTS

Course Outcome:

On successful completion of teaching-learning and valuation activities, a student would be able to:

1. Learn and appreciate computer architecture with an emphasis on system design - performance and analysis.
2. Elevate computer architecture related discussions and thoughts to performance improvement of storage and interconnect mechanisms in multi-core systems.
3. Understand and analyze events happening at hardware level with the help of open source simulators.
4. Enable exploration of future directions in computer architecture research.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	2	2		1					1	1	2	3	
CO 2	3	3	3	3	3			1	2	2	2	3	2	
CO 3	3	3	1	3	3			1	2	2	2	3	2	2
CO 4	2	2		3		1				3	1	3	2	

1-Slightly; 2-Moderately; 3-Substantially

Module I

Processor design trends - instruction pipeline concepts - out-of-order execution - introduction to superscalar processors - Cache memory concepts and optimization techniques - DRAM organization - design concepts in memory controllers.

Module II

Tiled Chip Multicore Processors & Network-On-Chip - Introduction to TCMP - Multicore processors - communication issues in TCMPs - role of NoCs - topology schemes - routing – deterministic and adaptive routings - input and output selection strategies - congestion managements with selection strategies.

Module III

NoC router micro architecture - input buffered routers - flow control techniques - virtual channels and deadlock management - allocators and arbiter algorithms for crossbar switch - Introduction to deflection routers – (Bufferless design) - minimally buffered router designs - compression and prefetch aware NoC designs.

Module IV

Need for QoS at on-chip shared resources like caches, NoC and memory controllers - cache management techniques for multi-core systems – Emerging trends in Network on chips - Introduction to wireless and optical NoCs – Concepts in TCMP systems.

Text books:

1. John L. Hennessy, David A. Patterson, *Computer Architecture-A Quantitative Approach,* Morgan Kaufman Publishers ,6/e, (2017), ISBN 9780128119051
2. W. Dally and B. Towles, *Principles and Practices of Interconnection Networks,* Morgan Kaufmann Publishers Inc., 1/e, (2004), ISBN 9780122007514

References:

3. Dezso sima, Terence Fountain, Peter Kacsuk, *Advanced Computer Architectures-A Design Space Approach*, , Pearson Education, 1/e, 2002, ISBN 9788131702086.
4. Bruce Jacob, Spencer W. Ng, David T. Wang, *Memory System-Cache, DRAM and Disk*, Morgan Kaufman Publishers Inc., (2007), ISBN 9780123797513

23-203 -0805 MULTIMEDIA COMMUNICATION SYSTEM

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to:

1. Understand principles behind multimedia information representation and digitization.
2. Familiarise common techniques for compressing different media types.
3. Implement lossless compression algorithms like Huffman, LZW, and arithmetic coding and apply lossy transforms such as DCT, wavelets for image/video compression.
4. Analyze tradeoffs between compression ratio, quality, and complexity for various codec designs.
5. Assess evolution of multimedia compression standards over generations and evaluate the suitability of different compression schemes for multimedia applications.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	1				1		2				1	3	
CO 2	3	1				1		2				2	2	
CO 3	3											1	2	2
CO 4	3	1										3	2	2
CO5													2	

1-Slightly; 2-Moderately; 3-Substantially

Module I

Introduction to Multimedia: Multimedia applications. Multimedia Information Representation, digitization principles, Text, Images, Audio, Fundamental Concepts in Video, Color in Image and Video RGB CMY, YUV YC_BC_R, Digital Video

Module II

Multimedia Compression Techniques:

Lossless Compression – Run Length Coding,Statistical Coding, Huffman Coding, Dictionary Coding, Arithmetic Coding. Lossy Compression - Transform coding, DFT, DCT, Harr Transform, KLT, Wavelet Transforms, Embedded Zero Tree Coder.

Module III

Audio Compression: Basic Audio Compression Techniques- Quantization, Non-linear Quantization, Differential Encoding, Linear Prediction Coding- LPC, DPCM, DM, Adaptive DPCM. Speech compression. MPEG audio coders, Dolby audio coders.

Module IV

Image and Video Compression: JPEG Standards-Baseline JPEG, JPEG Models. Basic Video Compression Principles, and standards H.261 and MPEG series

Text books:

1. Fred Halsall, *Multimedia Communications: Applications, Networks, Protocols and Standards,* Pearson, (2012)
2. Li, Ze-Nian, Drew, Mark S, *Fundamentals of Multimedia,* Springer Science & Business Media, (2014)

References:

3. Krishna Kumar D N, *Multimedia communication*, Pearson (2010), ISBN 9788131732380.
4. K.Sayood, *Introduction to Data Compression*, Morgan Kauffman 4/e, (2012), ISBN 9780124157965
5. Iain E. G. Richardson. *H.264 and MPEG-4 Video Compression,* John Wiley & Sons (2003) ISBN 978-0470848371

23-203 -0806 ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY

Course outcomes:

At the end of this course, the student should be able to:

1. Identify Standards.
2 Compare EMI test methods.
3. Apply EMI mitigation techniques.
4. Learn about the precautions and shielding used in electronic gadgets.
5. Calculate EMI of a system.
6. EMC Design of PCBs.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	2	2										2	2	
CO 2	3	1			1							2	2	
CO 3	3	3	1	2	1							1	2	2
CO 4	3	2	2	3	2	3	2	2			1	2	2	
CO 5	3	2	2		1			1				2	2	2
CO 6	3	3	3	2	1	2	1	1	1	1	2	2	1	3

1-Slightly; 2-Moderately; 3-Substantially

Module I

Introduction to EMC, Aspects of EMC, decibels and common EMC units. EMC requirements for Electronic systems: Governmental requirements, Product requirements. FCC and CISPR classifications. Antennas, elemental dipole antennas, characterization of antennas, Directivity and gain, effective aperture, Antenna Factor. Broad band Measurement Antennas.

Module II

Non Ideal behavior of components; Wires, resistance and internal inductance of wires, external inductance and capacitance of parallel wires, Per unit length parameters of Resistors, Capacitors, and Inductors, Ferrites and common-mode chokes. Conducted Emission, The Line Impedance Stabilization Network (LISN).

Module III

Spectra of digital circuit waveforms, spectral bounds for Trapezoidal waveforms, Spectrum analyzers. Radiated Emissions and Susceptibility: Simple emission models for wires and PCB lands, Differential-mode versus common-mode currents, differential-mode current model, common-mode current model. Simple susceptibility models for wires and PCB lands. Power supply and filter placement.

Module IV

Common and differential mode current gain, power supply filters. Electro static Discharge (ESD), origin of ESD and effects of ESD. Shielding, shielding effectiveness –far-field sources, shielding effectiveness –near-field sources. EMI measurement: Open Area Test sites, Anechoic chamber, TEM Cell, GTEM Cell

Text book:

1. Clayton R. Paul, *Introduction to Electromagnetic compatibility*, Wiley Blackwell, 3/e, (2022), ISBN 978-1119404347.
2. V. Prasad Kodali, *Engineering Electromagnetic Compatibility Principles, Measurements, technologies and Computer Models,* Wiley -IEEE, (2010), ISBN 978-0780347434

References:

3. Henry W Ott, *Electromagnetic Compatibility Engineering,* John Wiley and Sons, 1/e, (2009), ISBN-13: 978-0470189306
4. Archambeault Bruce R, Ramihi Omar M, Brench, *EMI/EMC Computational Modeling Handbook*, Springer publications, (2013), ISBN 9781475751260

23-203-0807 ASIC DESIGN

Course outcome:

On successful completion of teaching-learning and valuation activities, a student would be able to:

1. Understand basics of ASIC design flow and libraries.
2. Design combinational and sequential ASIC circuits using HDL.
3. Analyze tradeoffs in using full-custom versus programmable ASIC design styles.
4. Evaluate floor planning, placement and routing algorithms.
5. Assess recent trends in ASIC technologies, tools and design methodologies.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	1	1	1	1							1	3	
CO 2	3	3	3	1	3							1	2	3
CO 3	3	2	3	1	1							1	2	2
CO 4	3	3	3	1	1							1	2	2
CO 5	3	2	3	1	1							1	2	

1-Slightly; 2-Moderately; 3-Substantially

Module I

Introduction to ASICs, Full custom, Semi-custom and Programmable ASICs, ASIC Design flow, ASIC cell libraries. CMOS Logic: Data path Logic Cells: Data Path Elements, Adders: Carry skip, Carry bypass, Carry save, Carry select, Conditional sum, Multiplier (Booth encoding), Data path Operators, I/O cells.

Module II

Programmable ASICs, Anti-fuse, Static RAM, EPROM and technology, Programmable ASIC logic cell: Altera flex1 I/O cells: DC output, AC output, Clock input, Interconnects: Actel ACT & amp; Xilinx LCA, Low level design entry: Hierarchical design entry.

Module III

Simulation, Synthesis and Testing Basics of HDL, simulation, types of simulation, Synthesis of combinational circuit, FSM synthesis, Memory synthesis, static timing analysis, Fault simulation and ATPG algorithm.

Module IV

Floor planning, Placement and Routing, Floor planning: Goals and objectives, Floor planning tools, Channel definition, I/O and Power planning and Clock planning. Placement: Goals and Objectives, Min-cut Placement algorithm, Iterative Placement Improvement, Physical Design Flow. Routing: Global Routing: Goals and objectives, Global Routing Methods, Back- annotation. Detailed Routing: Goals and objectives, Measurement of Channel Density, Left- Edge and Area-Routing Algorithms. Special Routing, Circuit extraction and DRC.

Text books:

1. Michael John Sebastian Smith, *"Application - Specific Integrated Circuits"* Addison- Wesley Professional, 2005.
2. Neil H.E. Weste, David Harris, and Ayan Banerjee, *"CMOS VLSI Design: A Circuits and Systems Perspective"*, , Addison Wesley/ Pearson education, 3/e, (2011).

References:

3. Design manuals of Altera, Xilinx and Actel.
4. Vikram Arkalgud Chandrasetty, *"VLSI Design: A Practical Guide for FPGA and ASIC Implementations",* Springer, (2011), ISBN: 978-1-4614-1119-2.
5. Rakesh Chadha, Bhasker J., *"An ASIC Low Power Primer",* Springer, (2015) ISBN: 978-1489991508

23-203-0808 ELECTRIC VEHICLE DESIGN

Course Outcomes:

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

1. Explain the history, market dynamics, and policy landscape related to electric and hybrid vehicle adoption
2. Analyze the power flow and energy efficiencies of different hybrid and electric powertrain configurations
3. Evaluate and compare motor drives, including DC motors, induction motors, and BLDC motors for vehicle applications
4. Design basic controllers and select appropriate interfaces for electric vehicle motors, power systems, and vehicle connectivity
5. Discuss communication protocols and networking technologies enabling vehicle connectivity and automation
6. Formulate and evaluate energy management strategies for hybrid vehicles, including comparisons of different control system approaches

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	**3**	**1**	**1**	**1**								**1**	**1**	
CO 2	**3**	**1**	**3**	**1**								**1**	**2**	
CO 3	**3**	**3**	**1**	**1**								**1**	**2**	
CO 4	**3**	**3**	**3**	**1**								**1**	**3**	
CO 5	**3**	**1**	**1**	**1**								**1**	**2**	**1**
CO 6	**3**	**1**	**1**	**1**								**2**	**2**	**1**

1-Slightly; 2-Moderately; 3-Substantially

Module 1: Introduction to Electric and Hybrid Vehicles: History of hybrid and electric vehicles, Technology scenario, Market scenario, Policies and regulations, Vehicle Components, Basics of vehicle performance, Mathematical models to describe vehicle performance, General layout, comparison, Advantages and disadvantages of EV and Hybrid EV, vehicle power source characterization, transmission characteristics.

Module 2: Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, Controllers and sensors, power flow control in hybrid drive-train topologies, Introduction to electric components used in hybrid electric vehicles

Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive- train topologies, power flow control in electric drive-train topologies.

Module3: Electric motor drives: Electric drive Components, Introduction to electric motors used in hybrid and electric vehicles: Characteristics and types of DC motors, Induction Motors, BLDC motors, Separately excited DC motor speed control, V/f control of induction motor drive, Comparison of all motors, Energy Storage Requirements in Hybrid and Electric Vehicles

Module 4: Vehicle controllers and communication: Vehicle controllers, types. Vehicle Communications-OSI Seven-layer model, In vehicle networks, Controlled area network. Energy management strategies used in hybrid and electric vehicles-classification, comparison

Text book:

1. Iqbal Hussein, *Electric and Hybrid Vehicles: Design Fundamentals*, CRC Press, (2021) ISBN 9780367693930

References:

2. K Sundareswaran, *Elementary Concepts of Power Electronic Drives,* CRC Press, (2019) ISBN 978-1138390492
3. James Larminie, John Lowry, *Electric Vehicle Technology Explained*, Wiley, 2/e, (2012), ISBN 978-1-119-94273-3
4. Seth Leitman, Bob Brant, *Build Your Own Electric Vehicle*, McGraw Hill, 3/e, (2013), ISBN 978-0071770569

23-203-0809 ARTIFICIAL INTELLIGENCE & ROBOTICS

Course Outcomes

On completion of this course the student will be able to

1. Understand different problem solving and search techniques in AI systems; fundamentals of knowledge representation, robot kinematics etc.
2. Implement informed search algorithms and apply parsing techniques for natural language understanding.
3. Analyze and compare heuristic search methods based on optimality, complexity etc. Evaluate different knowledge representation schemes.
4. Assess applications of AI techniques like expert systems, NLP, robotic systems etc.
5. Recommend knowledge representation and reasoning approaches for an application.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	1	1	1	1							2	2	
CO 2	3	1	3	1	1							2	2	2
CO 3	3	1	3	1	1							2	2	2
CO 4	3	1	3	1	2							2	2	
CO 5	3	1	3	1	2							2	1	

1-Slightly; 2-Moderately; 3-Substantially

Module I:

Scope of AI-Introduction to Artificial Intelligence. Applications- Games, theorem proving, natural language processing, vision and speech processing, robotics, expert systems. AI techniques- search knowledge, abstraction.

Module 2:

Problem Solving-State space search; Production systems, search space control: depth first, breadth-first search, heuristic search - hill climbing, best-first search, branch and bound. Problem Reduction, Constraint Satisfaction End, Means-End Analysis

Module 3

Knowledge Representation: Knowledge Representation issues, first order predicate calculus, Horn Clauses, Resolution, Semantic Nets, Frames, Partitioned Nets, Procedural Vs Declarative knowledge, Forward Vs Backward Reasoning. Understanding Natural Languages: Introduction to NLP, Basics of Syntactic Processing, Basics of Semantic Analysis, Basics of Parsing techniques. Generative AI: Generative models and their applications, Introduction to generative adversarial networks (GANs)

Module 4

Fundamentals of Robotics, Robot Kinematics: Position Analysis, Dynamic analysis and Forces, Robot Programming languages & systems: Introduction, the three levels of robot programming, requirements of a robot programming language, problems peculiar to robot programming languages.

Text books:

1. Russell Stuart, Norvig Peter, "*Artificial Intelligence Modern Approach*", Pearson Education ,3/e, (2015), ISBN 978-9332543515
2. Robin R Murphy, *Introduction to AI Robotics* Bradford, (2019)

References:

3. Daniel Jurafsky and James H. Martin, "*Speech and Language Processing*", 3/e, Pearson, 2024.
4. Dan.W.Patterson, "*Introduction to Artificial Intelligence and Expert Systems*", Pearson Education, 1/e, (2015), ISBN 978-8120307773.
5. George Luger, *Artificial Intelligence: Structures and Strategies for Complex Problem Solving*, Pearson, 6/e, (2021), ISBN 978-9354493782
6. Steven M LaValle, "*Planning Algorithms" Cambridge, (*2006), ISBN 978-0521862059

23-203-0810 MULTIRATE SIGNAL PROCESSING

Course Outcomes:

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

1. Understand fundamentals concepts of multirate signal processing including sampling, Nyquist rates, decimation, interpolation, and implications in frequency domains
2. Design and implement standard FIR and IIR digital filter structures for sampling rate conversion using techniques like polyphase decomposition
3. Analyze computational efficiency and tradeoffs for different multirate filter implementations
4. Evaluate filter specifications and constraints for multirate sampling rate conversion operations
5. Assess and critique filtering techniques for sampling, resampling, reconstruction, and processing in applications like audio/video coding, software-defined radio, etc.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	1	1	1								1	3	
CO 2	3	3	3	3								1	2	3
CO 3	3	3	3	3	2							1	2	
CO 4	3	3	3	3	2							1	2	1
CO 5	3	3	3	1	2							1	2	

1-Slightly; 2-Moderately; 3-Substantially

Module 1

Multirate system fundamentals: The sampling theorem - sampling at sub Nyquist rate - Basic Formulations and schemes. Basic Multirate Operations-Decimation and Interpolation Time-Domain Representation of Down-Sampling and Up-Sampling, Frequency-Domain Characterization of Down-Sampling and Up-Sampling, Decimation and Interpolation Identities, Cascading, Sampling-Rate Alteration Devices, Polyphase Decomposition, Multistage Systems.

Module 2

Filters in Multirate Systems: Spectral Characteristics of Decimators and Interpolators, Filter Specifications for Decimators and Interpolators**.** FIR Filters for Sampling Rate Conversion: Direct Implementation Structures for FIR Decimators and Interpolators, Poly-phase Implementation of Decimators and Interpolators, Memory Saving Structures for FIR Poly-phase Decimators and Interpolators, Computational Efficiency of FIR Decimators and Interpolators

Module 3

IIR Filters for Sampling Rate Conversion: Direct Implementation Structures for IIR Filters for Decimation and Interpolation, Computational Requirements for IIR Decimators and Interpolators, IIR Filter Structures Based on Polyphase Decomposition. Sampling Rate Conversion by a Fractional Factor: Sampling Rate Conversion by a Rational Factor, Spectrum of the Resampled Signal, Polyphase Implementation of Fractional Sampling Rate Converters, Rational Sampling Rate Alteration with Large Conversion Factors, Sampling Rate Alteration by an Arbitrary Factor, Fractional Delay Filters

Module 4

Lth Band digital Filters-Definitions and properties, polyphase Implementation, Half band IIR/FIR filters, complimentary digital filter pairs-definitions, analysis and synthesis filter pairs. Solving complex filtering problems using multirate techniques, multi stage narrowband filters.

Text book:

1. N.J. Fliege. *Multirate Digital Signal Processing: Multirate Systems - Filter Banks – Wavelets*, John Wiley (1999), ISBN: 9780471492047

References

2. Ljiljana Milic, *Multirate filtering for Digital Signal processing- MATLAB applications*, Information Science Reference, (2009), ISBN 9781605661780
3. R.E. Crochiere. L. R, *Multirate Digital Signal Processing*, Prentice Hall. Inc.1983
4. Fredric J Harris, *Multirate Signal Processing for Communication Systems*, River publishers, 2/e, (2021), ISBN 978-8770222105

23-203-0811 OPTIMIZATION TECHNIQUES & ALGORITHMS

Course Outcomes:

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

1. Understand concepts of objective functions, constraints, gradient descent in optimization.
2. Analyze tradeoffs between exploration and exploitation in heuristic optimization methods.
3. Evaluate convergence and optimality of nature-inspired algorithms.
4. Assess effectiveness of classical vs metaheuristic optimization methods.
5. Evaluate software tools like MATLAB, Python for optimization.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	3	1	3								1	2	
CO 2	3	3	3	3								1	2	3
CO 3	3	3	3	3								1	2	3
CO 4	3	3	3	3								1	2	2
CO 5	3	3	3	3	3							2		3

1-Slightly; 2-Moderately; 3-Substantially

Module 1: Introduction to Optimization

Formulation of optimization problems, Classification of optimization problems, Optimization algorithms - Calculus based, Enumerative, Randomized, Constraints and objective functions

Module 2: Classical and Heuristic Optimization

Single variable optimization, Multivariable optimization without constraints, Multivariable optimization with equality constraints, Gradient descent methods, Newton's method, Nature-inspired optimization algorithms

Global and Local Minimum: Issues with gradient-based methods getting stuck in local minimum, Techniques for searching global minimum -Multi-start methods, Simulated annealing, Evolutionary and genetic algorithms, Particle swarm optimization, Ant colony optimization, Comparison of global search methods, Hybridizing gradient descent with global search.

Module 3: Advanced Numerical Optimization

Linear programming and Simplex method, Quadratic and Convex optimization, Dynamic programming, Meta-heuristics for combinatorial optimization, Multi-objective optimization

Module 4: Applications in Signal Processing and Communications

Optimization of filter design, Beamforming optimizations, Optimization in wireless sensor networks, Optimization of communication systems, Deep learning optimization algorithms.

Case study: Apply genetic algorithms for RF filter design optimizations using Matlab/python

Text book:

1. Singiresu S Rao, *Engineering Optimisation- Theory and Practice*, Wiley, 5/e, (2019), ISBN 9781119454717

References:

2. Andreas Antoniou, Wu-Sheng Lu, *Practical Optimization: Algorithms and Engineering Applications*, Springer, 2/e, (2021)
3. Olympia Roeva, *Real-World Applications of Genetic Algorithms*, InTech, (2012), ISBN 9789535101468
4. Jürgen Branke, Kalyanmoy Deb, Kaisa Miettinen and Roman Słowiński, *Multiobjective Optimization: Interactive and Evolutionary Approaches,* Springer, (2008), ISBN 9783540889076
5. A. Ravindran, K. M. Ragsdell , G. V. Reklaitis, *Engineering Optimization Methods And Applications*, Wiley,2/e, (2008), ISBN 9788126509331

23-203-0812 BIO-INFORMATICS

Course Objectives:
To appreciate the diverse field of study and apply electronic engineering skill in the new discipline

Course Outcomes:
On successful completion of teaching-learning and valuation activities, a student would be able to
1. Understand the structure and function of biomolecules.
2. Understand sequence alignment algorithms and phylogenetic analysis.
3. Implement Needleman-Wunsch and Smith-Waterman algorithms for sequence alignment.
4. Analyze genomic signals and microarray data for gene identification and expression profiling. Evaluate algorithms for sequence alignment, phylogenetic trees.
5. Assess computational methods for modeling molecular structure and interactions.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	1	1	1								1	2	
CO 2	3	1	1	1								1	2	
CO 3	3	3	3	2	2							1	2	
CO 4	3	1	3	2	2							1	2	
CO 5	3	1	3	1								1	2	1

1-Slightly; 2-Moderately; 3-Substantially

Module I
Basic Concepts of Molecular Biology: Cells - Chromosomes, DNA, RNA, Proteins, Central dogma of molecular biology, Genomes and Genes - Genetic code, Transcription, Translation and Protein synthesis. Web based genomic and proteomic data bases: NCBI, GenBank

Module II
Sequence alignments – Dot plot-Pair-wise sequence alignments - local and global -Sequence similarity and distance measures - Smith- Waterman algorithm, Needleman-Wunch algorithm, Multiple sequence alignment –Sum-of-Pairs measure - Star and tree alignments – PAM and BLOSUM, Phylogenetic analysis

Module III
Informational view of Genomic data, Genomic Signal Processing, DNA Spectrograms, Identification of protein coding regions, Gene expression, Microarrays, Microarray image analysis

Module IV
Gene structure in Prokaryotes and Eukaryotes: Molecular Structure Prediction: Basic concepts and terminologies related to molecular structures, Basic molecular Visualization, RNA secondary structure prediction, Protein folding problem, Protein Threading, Protein Visualization, Introduction to Drug Discovery.
Case Study
Software Tools: Use of Tools for basic and specialized sequence processing such as: BLAST, FASTA, RasMol, Phylip, ClustalW

References:

1. Jonathan Pevsner, *Bioinformatics and Functional Genomics*, Wiley-Blackwell, 3/e, (2015), ISBN 9781118581780
2. P M Selzer, O Koch, *An Introduction to Applied Bioinformatics*, Springer, 2/e, (2018), ISBN 9783319683010
3. E Mathe, S Davis, *Statistical genomics- methods and Protocols*, Springer, (2016), ISBN 9781493935765
4. V Bolon-Canedo, A Alonso-Betanzos, *Microarray Bioinformatics*, Springer, (2020), ISBN 978149399444

23-200-0817 CONSTITUTIONAL LAW

Course Outcomes:

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

1. Configure the preamble and fundamental rights.
2. Actuate the governance and functioning of constitutional functionaries.
3. Describe the functions of legislative bodies.
4. Decipher the judiciary system and its role in governance.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1						**3**	**2**	**2**	**1**			**2**	**2**	
CO 2						**3**	**2**	**2**	**1**			**1**	**2**	
CO 3						**2**	**2**	**2**					**2**	
CO 4						**2**	**2**	**2**					**2**	

1-Slightly; 2-Moderately; 3-Substantially

Module I: Introduction

Constitution Law – Constitutional Assembly Debates – Constitution of India – Basic Features of Indian Constitution – Preamble – Structure and Content of Indian Constitution

Module II: Fundamental Rights

Rights – Fundamental Rights – Definition of State – Fundamental Rights under Indian Constitution – Right to Equality – Untouchability – Title – Right to Life Cultural and Educational Rights of Minorities - Enforcement of Fundamental Rights

Module III: Directive Principles of State Policy & Fundamental Duties

DPSP's – Relationship between DPSP and Fundamental Rights – Conversion of DPSP into Fundamental Rights – Role of Judiciary – Judicial Activism – PIL - Fundamental Duties

Module IV: Constitutional Organs

Legislative Organs – Parliament – Lok Sabha, Rajya Sabha - State Legislatures - Executive Organs - President, Vice President, Council of Ministers - Judicial Organs – Supreme Court and High Courts – Other Constitutional Bodies – Election Commission - Comptroller and Auditor General of India, etc.

Text book:

1. Durga Das Basu, *Introduction to the Constitution of India*, Educational printed, 26/e, (2022), ISBN 9788180389184

References:

2. D.C. Gupta, *Indian Government and Politics*, Vikas Publishing House, 8/e, (2018), ISBN 9780706987782.
3. H.M.Sreevai, *Constitutional Law of India*, Universal Law Publication,4/e, (2015), ISBN 9788175344068.

23-203-0813 PROJECT PHASE II

Course Outcomes:

On successful completion, a student would be able

1. Realize various steps involved in conducting a project work, like literature survey, methodology adopted - field study-survey-experiments-numerical work, analysis of the data to arrive at final results and conclusions, etc.
2. Initiate a habit of proper report writing with all of its major components, proper style of writing and preparation of a distinct abstract and carved out conclusions.
3. Conceive the pros and cons of working in a team and the wonderful results which could evolve through team-work.
4. Present and defend self-prepared and corrected report (with the help of project guide) of a self-created work to a peer audience
5. Analyze and formulate a socially relevant problem

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3					3	3	3	3			3	2	2
CO 2	3					3	3	3	3			3	2	
CO 3	3					3	3	3	3			3	2	
CO 4	3					3	3	3	3			3	2	2
CO 5	3	3				3	3	3	3			3	3	

1-Slightly; 2-Moderately; 3-Substantially

Each batch of students shall develop the project designed during the VII semester. The implementation phase shall proceed as follows:

- For hardware projects, practical verification of the design, PCB design, fabrication, design analysis and testing shall be done.
- For software projects, a proper front-end (GUI) if applicable shall be designed. A detailed algorithm level implementation, test data selection, validation, analysis of outputs and necessary trial run shall be done.
- Integration of hardware and software, if applicable, shall be carried out.
- A detailed project report in the prescribed format shall be submitted at the end of the semester. All test results and relevant design and engineering documentation shall be included in the report.
- The work shall be reviewed and evaluated periodically.

A committee consisting of the Project Coordinator (appointed by the Head of the Department / Division), project guide and at least one senior faculty member will carry out the assessment based on at least one interim review and a final review just before the submission of the project report.

The final evaluation of the project shall include:

- Presentation of the work,
- Oral examination,
- Demonstration of the project against design specifications,
- Complete project report

GUIDELINES FOR EVALUATION

i.	Regularity and progress of work	40
ii.	Work knowledge and Involvement	40
iii.	End semester presentation and oral examination	40
iv.	Level of completion and demonstration of	40
v.	Project Report - Presentation style and content	40
	Total	200 marks

Note: Points (i) and (ii) to be evaluated by the respective project guide and the project coordinator based on continuous evaluation (iii)-(v) to be evaluated by the final evaluation team

23-203-0814 COMPREHENSIVE VIVA VOCE

Course Objective:

To test the student's learning and understanding of the theory and applications of the various concepts taught during the entire course of their program and to prepare the students to face interviews in both the academic and industrial sectors

Course Outcomes:

On successful completion, a student would be able to

1. Refresh all the subjects covered during the programme
2. Gain good knowledge of theory and practice
3. Develop oral communication skills and positive attitude
4. Face technical interviews with confidence

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	1	1				2	1	1		3		3	2	
CO 2	2	1				2	1	1		3		3	2	
CO 3	3	1				2	1	1		3		3	2	
CO 4	2	1				2	1	1		3		3	2	

1-Slightly; 2-Moderately; 3-Substantially

Each student is required to appear for a viva-voce examination at the end of the complete course work. The examination panel shall comprise of Head of Division or his/her nominee and one senior faculty of the Division and an external expert appointed by the University. The examiners shall evaluate the students in terms of their conceptual grasp of the program of study and practical/analysis skills in the field of Electronics and Communication

23-203-0815 INTERNSHIP-IV

Course Outcomes:

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

1. Understand the real time technical/managerial skills required and relevant to the subject area of internship
2. Initiate a habit of proper daily diary writing with adequacy and quality of information recorded, drawing and sketches and data, thought process and the proper organisation of the information gained during the internship.
3. Conceive the pros and cons of working in a real time industrial environment and the wonderful results which could evolve through team-work.
4. Present and defend self-prepared and corrected internship report (with the help of internship guide/industry mentors) of a self-created work to a peer audience.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	1					1	2	3		2		3	2	
CO 2		1	1			3	1	3	2	3		3	1	
CO 3	2	2	1		3	1	2	3	1	1	2	2	2	
CO 4						2			3	2	2	1	2	1

1-Slightly; 2-Moderately; 3-Substantially

Internship Guidelines

- An internship plan has to be prepared by the interns incorporating the job description/internship duties, name of the project, if any and internship schedule and expected learning outcomes in consultation with industry supervisor/mentor and institute faculty.
- A detailed training report in the prescribed format shall be submitted at the end of the internship.
- Training Certificate from the industry for the prescribed period shall be submitted at the end of the internship.
- The work shall be reviewed and evaluated periodically.
- Orientation of interns, resource requirement of interns, monitoring of intern's progress on a daily basis shall be carried out by the industry offering internship in addition to ensuring safety and welfare of the interns.

A committee consisting of the Internship Coordinator (nominated by the Head of the Department/Division), faculty mentor, and at least one senior faculty member at the level of Associate Professor or above will carry out the final review.

Guidelines for evaluation:

Regularity and progress of work	40
Work knowledge and Involvement	40
Semester End presentation and oral examination	40
Level of completion of internship	40
Internship Report – Presentation style and content	40
Total	200 Marks

MINOR IN ELECTRONICS

23-203 -0310 PRINCIPLES OF COMMUNICATION

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able

1. To understand various continuous-wave modulation and demodulation techniques for communication systems, probability theory, random variables and random processes
2. To study the generation, transmission and reception of different modulated signals, correlation, covariance and power spectral density of stationary random processes
3. To analyze the signal spectrum, bandwidth and power requirements, and effect of noise in different modulation schemes
4. To apply the knowledge to solve the basic problems in communication systems

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	2			1					1		2	3	
CO 2	3	1	1	1	2	1	1	1	1	1		1	2	
CO 3	3	3	2	2	2	2	1	1	1	1	1	1	2	
CO 4	3	2	2	2	2	1	1	1	1	1	1	1	2	

1-Slightly; 2-Moderately; 3-Substantially

Module I

Introduction: Elements of communication systems, Electromagnetic spectra, Need for modulation. Noise in communication system. Amplitude modulation (AM), Double-side band suppressed carrier (DSB-SC) modulation Single sideband modulation (SSB) – spectrum, power, efficiency of all the three variants. (Study of only tone modulation in DSB-SC, AM, and SSB.) Amplitude-modulator implementations – switching modulator, balanced modulator. AM demodulators -- Coherent demodulator. Envelope detector.

Module II

Angle modulation: concept of instantaneous frequency- relationship between FM and PM- power and bandwidth – Carson's rule. FM generation –direct, indirect method- narrowband and wideband FM. FM demodulation –slope detection. Comparison of AM and FM. Superheterodyne receivers

Module III

Pulse Modulation & Waveform Coding Techniques: PAM, PWM, PPM, Multiplexing- TDM, FDM. PCM system- quantization process- uniform and nonuniform quantization, Quantization Noise & SQNR, Robust quantization, companding- A Law and μ Law characteristics. DPCM-transmitter and receiver. Delta Modulation - transmitter and receiver, quantization error. Adaptive delta modulation.

Module IV

Digital modulation schemes: Baseband BPSK, BFSK, BASK systems and the signal constellations. Base band QPSK system and Signal constellations. Plots of BER Vs SNR (Analysis not required). QPSK transmitter and receiver. Quadrature amplitude modulation.

Text book:

1. George Kennedy, *Electronic communication systems*, McGraw Hill, 6/e ,(2017), ISBN 9789352606603

References:

2. Simon Haykin and Michael Moher, *Communication Systems*, John Wiley & Sons, 5/e, (2017).
3. B. P. Lathi and Zhi Ding, *Modern Digital and Analog Communication Systems*, Oxford University Press, 4/e,(2017)
4. Simon Haykin, *Digital Communications*, John Wiley& Sons, (2015)

23-203 -0410 SIGNAL PROCESSING

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to

1. understand the concept of a signals and systems, their characteristics, classification and analysis using differential /difference equations
2. understand the concept of impulse response and perform convolution
3. predict and analyze the response of LTI systems to various types of input signals
4. understand Sampling theorem and the need for sampling and reconstruction
5. analyze LTI systems using Laplace transforms /Z transform
6. understand and evaluate the frequency response of LTI systems using CT/DT Fourier series and transforms.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	1	1				1	1				1	2	
CO 2	3	2	1									1	2	2
CO 3	2	2	1		1	1		1	1	1		1	2	2
CO 4	3	1	1			1						1	2	
CO 5	2	1	1		1	1		1	1	1	1	1	2	
CO 6	2	1	1		1			1		1		1	2	

1-Slightly; 2-Moderately; 3-Substantially

Module I

Continuous time (CT) and Discrete time (DT) Signals - Introduction - exponential and sinusoidal - unit step and impulse functions / sequences – Classification of signals - CT and DT Systems - Properties of systems - Linear time-invariant (LTI) systems –Basic operations on signals - The representation of signals in terms of impulses - convolution - Properties of LTI systems. Differential/Difference equation representation.

Module II

Laplace transform - The region of convergence for Laplace transforms - The inverse Laplace transform - Properties of the Laplace transform - Analysis and characterization of First-order and second-order LTI systems using the Laplace transform.

Fourier Series and Transforms – Fourier series representation of Continuous time periodic signals - Convergence of Fourier series - Continuous- time Fourier transform representation of Aperiodic signals.

Module III

Sampling – Introduction - Representation of a continuous-time signal by its samples - the sampling theorem –The effect of undersampling: aliasing. Discrete-time Fourier series - Properties - Discrete-time Fourier transform – Properties-Discrete Fourier Transform (DFT) – Properties – circular convolution – Linear convolution.

Module IV

Z-transform- The region of convergence – Pole zero plot - Properties of the z-transform - Inverse z-transform (partial fraction method) - Analysis and characterization of LTI systems using z-transforms. mapping between s and z domain, causality and stability.

Reference:

1. Alan V Oppenheim, Alan S Willsky, *Signals and Systems*. Prentice Hall India ,2/e, (2010)

23-203-0513 MINI PROJECT

Course Objectives:

To design a circuit, the integration to make it as a product, and the documentation of that work.

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able

1. To analyze the circuit designing capability and the documentation capability.
2. To understand the process of making an electronic product.

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	1	2	3						1			3	2	2
CO 2	1	1	3						1			3	2	2

1-Slightly; 2-Moderately; 3-Substantially

The objective of this course is to apply the fundamental concepts of different courses learned in respective Minor Streams. Mini project enables the students to boost their skills, widen the horizon of thinking and their ability to resolve real life problems.

HONORS

23-203-0515 LOW POWER VLSI

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to:

1. Analyze various sources of power dissipation in MOSFET
2. Apply various power reduction techniques to circuits.
3. Apply various clocked and non-clocked design styles for logic implementation.
4. Apply Adiabatic and reversible logic for circuit implementation

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	3	2	1	1							1	3	1
CO 2	3	3	2	1	1							1	3	
CO 3	3	3	3	1	1							1	3	
CO 4	3	3	3	1	1							1	3	

1-Slightly; 2-Moderately; 3-Substantially

Module 1: Sources of power dissipation in CMOS - Need for low power circuit design, Dynamic Power Dissipation: Charging and Discharging capacitance power dissipation, Short Circuit Power: Short Circuit Current of Inverter, Short circuit current dependency with input and output load, Glitching Power, Static Power Dissipation, Leakage Power Dissipation, Gate level power analysis: Capacitive, internal and Static power dissipation of gate level circuit.

Module 2: Power Reduction Techniques: Supply voltage Scaling Approaches**:** Multi VDD and Dynamic VDD, leakage power reduction Techniques – Transistor stacking, VTCMOS, MTCMOS, DTCMOS, Power gating, Clock gating for Dynamic power dissipation, Transistor and Gate Sizing for Dynamic and Leakage Power Reduction.

Module 3: Circuit design style- clocked design style- Basic concept, Domino logic (domino NAND gate), Differential Current Switch Logic. Non-clocked circuit design style - fully complementary logic. NMOS and pseudo –NMOS logic, differential cascade voltage switch logic (DCVS)

Module 4: Adiabatic switching – Adiabatic charging, adiabatic amplification, One stage and two stage adiabatic buffer, Adiabatic logic gates, pulsed power supplies, Reversible logic basic concepts.

Text books:

1. Gray Yeap, *Practical low power digital VLSI design*, Springer, 1998
2. Kaushik Roy, Sharat C Prasad, *Low power CMOS VLSI circuit design*, Wiley India, 2000
3. Christian Piguet, *Low power CMOS circuits*, Taylor & Francis, 2006

References:

1. Abdellatif Bellaouar, Mohamed I Elmasry, *Low power digital VLSI design*, Kluwer Academic, 1995
2. Anatha P Chandrakasan, Robert W Brodersen, *Low power digital CMOS Design*, Kluwer Academic, 1995
3. Kiat Seng Yeo, Kaushik Roy, *Low voltage, low power VLSI sub systems*, Tata McGraw Hill, 2004

23-203 -0616 DIGITAL IMAGE FORENSICS

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able to:

1. Identify image tampering
2. Identify the features and techniques that can trace back to the source camera of an image
3. Judge whether a digital image is authentic and distinguish between a photographic image and a computer generated image
4. Gain sufficient insights on how a digital image can be testified in a court of law by applying anti-forensic strategies

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	1	2	1								1	3	
CO 2	3	1	2	1								1	3	
CO 3	3	1	2	1								1	2	2
CO 4	3	1	2	1								1	3	

1-Slightly; 2-Moderately; 3-Substantially

Module 1

Digital camera image formation – hardware, processing and storage – Data recovery and extracting digital image evidence
Basic digital image storage formats

Module 2

Introduction to Digital image forensics – Storage file systems and fragmentation – carving. Source class identification – Sensor defects – Source camera identification using sensor fingerprints

Module 3

Methods to verify the authenticity of digital images – Natural image statistics
Identifying the attributes to detect tampered images – Geometry, illumination, lens, sensor, processing steps and image pipeline
Computer Generated images and Photographic image detection

Module 4

Practical approach to Digital image forensics – image forensic approaches in courtrooms
Anti-forensics – Definitions, practical considerations – classifications – removing traces of forgery and adding traces of authenticity

Text books:

1. Senear, H. T., and N. Memon. *"Digital Image Forensics: There is More to a Picture Than Meets the Eye [M]."* Springer Publishing Company, Incorporated (2012).
2. Shih, Frank Y., ed. "*Multimedia security: watermarking, steganography, and forensics*", CRC Press, (2017).
3. Joakim. Kavrestad. *"Fundamentals of Digital Forensics: Theory, Methods, and Real-Life Applications*". Springer Nature, (2020).

23-203-0718 RADAR SIGNAL PROCESSING

Course Outcomes:

On successful completion of teaching-learning and valuation activities, a student would be able

1. To apply Doppler principle to radars and hence detect moving targets, cluster, also to understand tracking radars
2. To understand the radar signal models and waveforms
3. To understand the Radar Signal acquisition and sampling in multiple domains
4. To apply basic radar signal processing techniques

CO PO PSO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3	2	3	1	1							1	2	
CO 2	3	1	1	1	1							1	2	2
CO 3	3	1	1	1	1							1	2	
CO 4	3	1	1	1	1							1	2	2

1-Slightly; 2-Moderately; 3-Substantially

Module I

Introduction- Basic Radar –The simple form of the Radar Equation, Radar Block Diagram, Radar Frequencies, Applications of Radar, The Origins of Radar. Detection of Signals in Noise- Receiver Noise and the Signal-to-Noise Ratio. Probability Density Functions- Probabilities of Detection and False Alarm. Integration of Radar Pulses- Radar Cross Section of Targets- Radar cross Section Fluctuations Transmitter Power-Pulse Repetition Frequency. Antenna Parameters, System losses, Other Radar Equation Considerations

Module II

Signal Models - Review of signal processing concepts and operations, Components of a radar signal, amplitude models, types of clutters, noise model and signal-to noise ratio, jamming, frequency models: the doppler shift, spatial models, spectral model. Sampling and quantization of pulsed radar signals - Domains and criteria for sampling radar signals, Sampling in the fast time dimension, Sampling in slow time: selecting the pulse repetition interval, sampling the doppler spectrum, Sampling in the spatial and angle dimension, Quantization, I/Q Imbalance and Digital I/Q.

Module III

Radar waveforms - Introduction, Matched Filter Receiver. Detection Criteria – Detectors - Automatic Detector, Matched filtering of moving targets, the ambiguity function, the pulse burst waveform, frequency-modulated pulse compression waveforms, Range sidelobe control for FM waveforms, stepped frequency waveform, Phase-modulated pulse compression waveforms, COSTAS Frequency Codes. Signal Management - Propagation Radar Waves, Atmospheric Refraction, Standard propagation, Nonstandard Propagation

Module IV

Doppler Processing-Alternate forms of the Doppler spectrum, Moving target indication (MTI), Pulse Doppler processing, dwell-to-dwell stagger, Pulse pair processing, additional Doppler processing issues, clutter mapping and the moving target detector, MTI for moving platforms: adaptive displaced phase centre antenna processing

Text book:

1. Merrill I. Skolnik," *Introduction to Radar Systems*", 3/e Tata Mc Graw-Hill 2017.
2. Marvin N. Cohen, Fred E. Nathanson, *Radar Design Principles-Signal Processing and the environment* PHI, 2/e, 2006.

References:

3. N.S.Nagaraja, *"Elements of Electronic Navigation Systems",* 2/e, TMH, 2017.
4. Peyton Z. Peebles, *"Radar Principles*", John Wiley, 2004
5. 4. J.C Toomay, *" Principles of Radar*", 2/e, PHI, 2007.