(DEEMED TO BE UNIVERSITY)

MECHANICAL ENGINEERING

CURRICULUM & SYLLABUS

APPLICABLE FOR B.TECH. STUDENTS

f

ADMITTED IN A.Y.2022-23

Course Structure										
Sl No	**Course Code**	**Course Title**	**Category**	**L**	**T**	**P**	**S**	**Cr**	**CH**	**Pre-requisite**
1.	22UC1101	Integrated Professional English	HSS	0	0	4	0	2	4	Nil
2.	22UC1202	English Proficiency	HSS	0	0	4	0	2	4	Nil
3.	22UC2103	Essential Skills for Employability	HSS	0	0	4	0	2	4	Nil
4.	22UC2204	Corporate Readiness Skills	HSS	0	0	4	0	2	4	Nil
5.	22UC0010	Universal Human Values & Professional Ethics	HSS	2	0	0	0	2	2	Nil
6.	22UC0007	Indian Heritage and Culture	HSS	2	0	0	0	0	2	Nil
7.	22UC0008	Indian Constitution	HSS	2	0	0	0	0	2	Nil
8.	22UC0009	Ecology & Environment	HSS	2	0	0	0	0	2	Nil
9.	22UC0011	Gender Sensitization	HSS	2	0	0	0	2	2	Nil
10.	22UC3105	Problem Solving Skills-I	HSS	0	0	2	2	1.5	4	Nil
11.	21UC3206	Problem Solving Skills-II	HSS	0	0	2	2	1.5	4	Nil
12.	22MT1101	Mathematics for Computing	BS	2	2	0	2	4.5	6	Nil
13.	22MT2102	Mathematics for Engineers	BS	2	1	0	0	3	3	Nil
14.	22ME2209	Numerical Computation for Mechanical Engineers	BS	3	0	2	0	4	5	Nil
15.	22UC1203	Design Thinking and Innovation	BS	0	0	4	0	2	4	Nil
16.	22PH1010	Mechanics (Science Elective - 1)	BS	3	1	0	0	4	4	Nil

17.	22CY1001	Chemistry (Science Elective - 2)	BS	3	0	2	0	4	5	Nil
18.	22SC1101	Computational Thinking for Structured Design	ES	3	0	2	6	5.5	11	Nil
19.	22ME1103	Design Tools Workshop-I	ES	0	0	4	0	2	4	Nil
20.	22ME1209	Design Tools Workshop-II	ES	0	0	4	0	2	4	Nil
21.	22SC1202	Design of Data Structures	ES	3	0	2	4	5	9	20SC1101
22.	22ME1002	Engineering Graphics & 2D Modelling	ES	1	0	4	0	3	5	Nil
23.	22ME2104	3D Modeling and Physical Prototyping (Workshop & 3D Modeling S/W)	ES	0	0	4	0	2	4	Nil
24.	22EE2205	Circuits and Electronics	ES	3	0	2	0	4	5	Nil
25.	22ME2105	Thermodynamics	ES	3	0	0	0	3	3	Nil
26.	22PH2007	Materials Technology	ES	2	0	0	0	2	2	Nil
27.	22ME2106	Fluid Mechanics & Hydraulic machines	PC	3	1	2	0	5	6	Nil
28.	22ME2210	Analysis of Thermal Systems (with CFD & (Linked to Project))	PC	3	1	0	4	5	8	21ME2105
29.	22ME3115	Heat Transfer	PC	3	0	2	0	4	5	Nil
30.	22ME2101	Mechanics of Solids	PC	3	0	2	0	4	5	21PH1010
31.	22ME2208	Mechanical Engineering Design & Innovation (Analysis S/W)	PC	2	0	0	4	3	6	21ME2101
32.	22ME2211	Kinematics of Machines (with Adams s/w)	PC	2	0	2	0	3	4	21PH1010
33.	22ME3118	Dynamics of Machines	PC	2	0	0	0	2	2	21PH1010
34.	22ME3113	Machine Design (Linked to Project)	PC	3	1	0	4	5	8	21ME2208

35.	22ME2107	Manufacturing Processes	PC	2	0	2	0	3	4	Nil
36.	21ME2212	Manufacturing Technology (Linked to Project)	PC	2	0	2	0	3	4	Nil
37.	21ME3116	Optimization Techniques	PC	2	0	0	0	2	2	Nil
38.	22ME4120	Instrumentation & Control	PC	2	0	0	4	3	6	Nil
39.	22ME3119	Robotics	PC	2	0	0	0	2	2	Nil
40.	22ME3114	Industry 4.0 & Design of Cyber Physical Systems	PC	3	0	0	0	4	4	
41.	PE-1	Professional Elective – 1	PE	2	0	2	0	3	4	-
42.	PE-2	Professional Elective – 2	PE	2	0	2	0	3	4	-
43.	PE-3	Professional Elective – 3	PE	2	0	2	0	3	4	-
44.	PE-4	Professional Elective – 4	PE	2	0	2	0	3	4	-
45.	PE-5	Professional Elective – 5	PE	2	0	2	0	3	4	-
46.	OE	Open Elective – 1	OE	3	0	0	0	3	3	Nil
47.	OE	Open Elective – 2	OE	3	0	0	0	3	3	Nil
48.	OE	Open Elective – 3	OE	3	0	0	0	3	3	Nil
49.	OE (21ME3217)	Management Elective(OE-4) Operations Management	OE	3	0	0	0	3	3	Nil
50.	OE	Foreign Language Elective(OE-5)	OE	2	0	0	0	2	2	Nil
51.	21IE2040	Social Internship	PR	0	0	0	4	1	4	Nil
52.	21IE3041	Technical Internship	PR	0	0	0	4	1	4	Nil

53.	21IE4042	Industry Internship	PR	0	0	0	4	1	4	Nil
54.	21IE2046	Project Based Learning -1	PR	0	0	0	6	1.5	6	Nil
55.	21IE2047	Project based learning -2	PR	0	0	0	6	1.5	6	Nil
56.	CC	Sports	CC	0	0	0	0	0	2	Nil
57.	21IE3043	Term paper	PR	0	0	0	4	1	4	Nil
58.	21IE3044	Mid Grad Capstone Project – I	PR	0	0	0	8	2	8	Nil
59.	21IE3045	Mid Grad Capstone Project – II	PR	0	0	0	8	2	8	Nil
60.	21IE4048/ 21IE4051/ 21IE4050	Project / Internship -1/Practice School	PR	0	0	0	16	4	16	Nil
61.	21IE4049/ 21IE4052/ 21IE4050	Project / Internship 2/Practice School	PR	0	0	0	16	4	16	Nil
		Total Credits						**167**		

Program Articulation Matrix (Mapping of Courses with POs)

S. No	Course Code	Course Name	Category	L	T	P	S	Cr	PO												PSO	
									1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	20UC1101	Integrated Professional English	HSS	0	0	4	0	2									1	1				
2	20UC1202	English Proficiency	HSS	0	0	4	0	2								1				1		
3	21UC2103	Essential Skills for Employability	HSS	0	0	4	0	2		1			1									
4	21UC2204	Corporate Readiness Skills	HSS	0	0	4	0	2		1			1									
5	21UC0010	Universal Human Values & Professional Ethics-I	HSS	2	0	0	0	2		1			1									
6	20UC0007	Indian Heritage and Culture	HSS	2	0	0	0	0	1													
7	21UC0008	Indian Constitution	HSS	2	0	0	0	0												1		
8	21UC0009	Ecology & Environment	HSS	2	0	0	0	0						2						1		
9	21UC0011	Gender Sensitization	HSS	2	0	0	0	2								2						
10	21UC3105	Problem Solving Skills-I	HSS	0	0	2	2	1.5														
11	21UC3206	Problem Solving Skills-II	HSS	0	0	2	2	1.5														
12	22MT1101	Mathematics for Computing	BS	2	2	0	0	4												2	2	
13	21MT2102	Mathematics for Engineers	BS	2	1	0	0	3	2													

S. No	Course Code	Course Name	Category	L	T	P	S	Cr	PO												PSO	
									1	2	3	4	5	6	7	8	9	10	11	12	1	2
14	22ME2209	Numerical Computation for Mechanical Engineers	BS	3	0	2	0	4	1	2	2	2	2				2		2			
15	21UC1203	Design Thinking and Innovation	BS	0	0	4	0	2	2													
16	21PH1010	Science Elective - 1 (Mechanics)	BS	3	1	0	0	4	1	1	3				2	1			1			
17	21CY1001	Science Elective-2(Chemistry	BS	3	0	2	0	4	1			1										
18	21SC1101	Computational Thinking for Design	ES	2	0	2	4	4			2		2									
19	21ME1103	Design Tools Workshop-I	ES	0	0	4	0	2	2		2											
20	21SC1209	Design Tools Workshop-II	ES	0	0	4	0	2			1	2	1								2	
21	21SC1202	Design of Data Structures	ES	3	0	2	4	5			1	2										
22	21ME1002	Engineering Graphics & 2D Modelling	ES	1	0	4	0	3	2				2								2	
23	21ME2104	3D Modeling and Physical Prototyping (Workshop & 3D Modelling S/W)	ES	0	0	4	0	2	2		2											
24	21EE2205	Circuits and Electronics	ES	3	0	2	0	4	2													
25	21ME2105	Thermodynamics	ES	3	0	0	0	4	2	2												
26	21PH2007	Materials Technology	ES	2	0	0	0	2														

S. No	Course Code	Course Name	Category	L	T	P	S	Cr	PO												PSO	
									1	2	3	4	5	6	7	8	9	10	11	12	1	2
27	22ME2106	Fluid Mechanics & Hydraulic Machines	PC	3	1	2	0	5		2		2										
28	22ME2210	Analysis of Thermal Systems (with CFD & (Linked to Project))	PC	3	1	0	4	6	2			2										
29	21ME3115	Heat Transfer	PC	3	0	2	0	4	2												2	
30	21ME2101	Mechanics of Solids	PC	3	0	2	0	4		2			2									
31	21ME2208	Mechanical Engineering Design & Innovation (Analysis S/W)	PC	2	0	0	4	3	2	3												3
32	21ME2211	Kinematics of Machines (with Adams s/w)	PC	2	0	2	0	3		2		2										
33	21ME3118	Dynamics of Machines	PC	2	0	0	0	2														
34	21ME3113	Machine Design (Linked to Project)	PC	3	1	0	4	5														
35	21ME2107	Manufacturing Processes	PC	2	0	2	0	3														
36	21ME2212	Manufacturing Technology (Linked to Project)	PC	2	0	2	0	3														
37	21ME3116	Optimization Techniques	PC	2	0	0	0	2														
38	22ME4120	Instrumentation & Control	PC	2	0	2	0	3														
39	22ME3119	Robotics	PC	2	0	0	0	2														

S. No	Course Code	Course Name	Category	L	T	P	S	Cr	PO												PSO	
									1	2	3	4	5	6	7	8	9	10	11	12	1	2
40	22ME3114	Industry 4.0 & Design of Cyber Physical Systems	PC	3	0	0	4	4														
41	21ME4051	THEORY OF ELASTICITY AND PLASTICITY	Engineering design	3	0	0	0	3														
42	21ME4052	FINITE ELEMENT METHOD		2	0	2	0	3														
43	21ME4053	MODELING ANALYSIS & DESIGN OF ROBOTIC SYSTEMS		2	0	2	0	3														
44	21ME4054	CREEP, FATIGUE AND FRACTURE MECHANICS		3	0	0	0	3														
45	21ME4055	ADVANCED STRENGTH OF MATERIALS		2	0	2	0	3														
46	21ME4056	MECHANICS OF COMPOSITE MATERIALS		2	0	2	0	3														
47	21ME4057	SUSTAINABLE DESIGN & SOCIAL INNOVATION IN ENGINEERING DESIGN		1	0	4	0	3														
48	21ME4061	MODERN MANUFACTURING PROCESSES	Smart manufacturing	2	0	2	0	3														
49	22ME4062	MACHINE TO MACHINE COMMUNICATION		2	0	2	0	3														
50	21ME4063	ADVANCED MATERIALS		3	0	0	0	3														
51	21ME4064	FLEXIBLE MANUFACTURING SYSTEMS		2	0	2	0	3														
52	21ME4065	ROBOTICS & INDUSTRIAL AUTOMATION		2	0	2	0	3														
53	22ME4066	REVERSE ENGINEERING &RAPID PROTOTYPING		3	0	0	0	3	1													

S. No	Course Code	Course Name	Category	L	T	P	S	Cr	PO												PSO	
									1	2	3	4	5	6	7	8	9	10	11	12	1	2
54	21ME4067	SUSTAINABLE DESIGN & SOCIAL INNOVATION IN SMART MANUFACTURING		2	0	2	0	3	2													
55	21ME4071	HYDROGEN AND FUEL CELL TECHNOLOGIES	Energy & CFD	2	0	2	0	3	1				2									
56	21ME4072	SOLAR ENERGY TECHNOLOGIES		2	0	2	0	3		2			2									
57	21ME4073	ADVANCED ENERGY STORAGE SYSTEMS		2	0	2	0	3	1	2			2									
58	21ME4074	ENERGY AUDIT AND MANAGEMENT		3	0	0	0	3	1		2											
59	21ME4075	COMPUTATIONAL FLUID FLOW AND HEAT TRANSFER-FDM APPROACH		2	0	2	0	3		2		2										
60	21ME4076	CFD FOR COMPRESSIBLE AND INCOMPRESSIBLE FLOWS		2	0	2	0	3		2			2									
61	22ME4077	THERMAL MANAGAMENT OF ELECTRIC AND ELECTRONIC SYSTEMS		3	0	0	0	3	2	1												
62	22ME4081	ROBOT MOTION PLANNING, DYNAMICS AND CONTROL	Robotics & mech	2	0	2	0	3	1	2	2										2	
63	22ME4082	ROBOT MANIPULATION AND WHEELED MOBILE ROBOTS		2	0	2	0	3	1	2	2										2	
64	22ME4083	MECHATRONICS : FUNDAMENTALS AND CORE CONCEPTS		2	0	2	0	3	2												2	
65	22ME4084	ARTIFICIAL INTELLIGENCE FOR ROBOTICS		2	0	2	0	3	1	2	2		2								2	

S. No	Course Code	Course Name	Category	L	T	P	S	Cr	PO												PSO	
									1	2	3	4	5	6	7	8	9	10	11	12	1	2
66	21EC3075	HUMAN MACHINE INTERFACE & BRAIN MACHINE INTERFACE	atronics	2	0	2	0	3														
67	21EC3074	COMPUTER VISION & APPLICATIONS		2	0	2	0	3														
68	21EC3072	AUTONOMOUS VEHICLES & AUTOMOTIVE ELECTRONICS		2	0	2	0	3														
69	22EE3241	POWER TRAIN DESIGN FOR ELECTRIC VEHICLE	Modern vehicle technology	2	0	2	0	3														
70	22ME4091	SOLAR ENERGY TECHNOLOGIES		2	0	2	0	3		1			2									
71	22ME4092	VEHICLE DYNAMICS		2	0	2	0	3		2												
72	22ME4077	THERMAL MANAGEMENT OF ELECTRIC AND ELECTRONIC SYSTEMS		2	0	2	0	3	2	1												
73	22EE4141	AI AND IOT FOR ELECTRIC VEHICLE		2	0	2	0	3														
74	22EE4142	COMMUNICATION PROTOCOLS & TESTING OF ELECTRIC VEHICLE		2	0	2	0	3														
75	22ME4094	AUTONOMOUS VEHICLES & AUTOMOTIVE ELECTRONICS		2	0	2	0	3														
76	21ME40B4	Robotics	OE	3	0	0	0	3	3													
77	21ME40B5	Mechatronics	OE	3	0	0	0	3	3													
78	21ME40B6	Operations Research	OE	3	0	0	0	3	3													

S. No	Course Code	Course Name	Category	L	T	P	S	Cr	PO												PSO	
									1	2	3	4	5	6	7	8	9	10	11	12	1	2
79	21ME40B7	Hybrid Electric vehicles	OE	3	0	0	0	3	3													
80	21ME40B8	Industry 4.0	OE	3	0	0	0	3	3													
81	21ME40B9	Industrial Automation	OE	3	0	0	0	3	3													
82	21ME40C1	Logistics & Supply chain management	OE	3	0	0	0	3	3													
83	21ME40C2	Total Quality Management	OE	3	0	0	0	3	3													
84	21ME40C3	Smart Mobility	OE	3	0	0	0	3	3													
85	21ME40C4	Managerial Economics for Engineers	OE	3	0	0	0	3	3													
86	OE (21ME3217)	Management Elective (OE-4) Operations Management	OE	3	0	0	0	3		2												
87	21IE2040	Social Internship	PR	0	0	0	4	1		2			2				2				2	2
88	21IE3041	Technical Internship	PR	0	0	0	4	1		2			2				2				2	2
89	21IE4042	Industry Internship	PR	0	0	0	4	0														
90	21IE2046	Project Based Learning -1	PR	0	0	0	6	1.5		3		3									2	2
91	21IE2047	Project based learning -2	PR	0	0	0	6	1.5		3			3				3				2	2
92	21IE3043	Term paper	PR	0	0	0	4	1		3			3				3				2	2

S. No	Course Code	Course Name	Category	L	T	P	S	Cr	PO												PSO	
									1	2	3	4	5	6	7	8	9	10	11	12	1	2
93	21IE3044	Mid Grad Capstone Project – I	PR	0	0	0	8	2		3			3				3				2	2
94	21IE3045	Mid Grad Capstone Project – II	PR	0	0	0	8	2		3			3				3				2	2
95	21IE4048/21IE4051/21IE4050	Project / Internship - 1/Practice School	PR	0	0	0	16	4		3			3				3				2	2
96	21IE4049/21IE4052/21IE4050	Project / Internship 2/Practice School	PR	0	0	0	16	4									2		2			

HUMANITIES AND SOCIAL SCIENCES

22UC1101 – INTEGRATED PROFESSIONAL ENGLISH

L-T-P-S : 0-0-4-0
Credits : 2
Contact Hours : 4
Pre-requisite : NIL

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand the concepts of grammar to improve communication, reading, and writing skills	PO10	2
CO2	Demonstrate required knowledge over Dos and Don'ts of speaking in the corporate context. Demonstrate ability to face formal situations / interactions.	PO9	2
CO3	Understand the varieties of reading and comprehend the tone and style of the author. Skim and scan effectively and appreciate rhetorical devices	PO9	2
CO4	Apply the concepts of writing to draft corporate letters, emails, and memos	PO10	3

Course Objective:

- To express themselves in English with greater fluency, accuracy and confidence
- To communicate with others in practical, business-oriented situations
- To handle variety of business contexts, from negotiating, to using telephone, making presentation.

Syllabus:

A)Basic Grammar - Countable and uncountable nouns, present simple and continuous, past simple and continuous – classroom practice – Understand and interpret Texts and work place situations B)Structural Pattern - Present continuous for future arrangements State verbs, Regular and irregular verbs, Voice, Modal verbs – Reporting on going tasks in the corporate world C)Descriptive and Qualitative Patterns: Adjectives and Adverbs classroom practice) Time Expressions, Comparatives and superlatives, Pronouns, Conditionals, Phrases and clauses (Including Relative)
a) Formal contexts: Being a PA, describing changes in a company Taking orders over the phone
b) Listening & Speaking: Participate in conversation with proper contextual language markers and turn taking. Classroom practice - Presenting context, reason, problem – Case analysis (short).
c) Body Language: Dos and Don'ts of one to one interaction, Telephone interaction Video/ web conferencing. Culture specific practices.
d) Work Etiquette- situation, ambience, team skills, time management and leadership ability.
a) Understand and assimilate main ideas and specific details. (250-300 words text of moderate difficulty)
b) Read for general understanding, interpreting, factual or specific information, for grammatical accuracy and information transfer.

c) Understand the general meaning of corporate context and office correspondence.
d) Understand short reports of predictable nature.
a) Internal Correspondence. Making notes on routine matters, such as, taking/ placing orders
b) Emails: Types of emails, salutations, vocabulary used in formal and informal (Including beginnings and endings)
c) Writing straight-forward, routine letters of factual nature

Reference Books:

1. Business Benchmark Book- Preliminary- 2nd edition Cambridge Press 2019.
2. Business Benchmark Book- Pre Intermediate to Intermediate- 2nd edition Cambridge Press 2019

Web Links:

1. https://www.cambridgeenglish.org/
2. https://learnenglish.britishcouncil.org,https://apps.apple.com/in/app/bec-from-cambridge/id1351207688https://play.google.com/store/apps/details?id=com.liqvid.bec

22UC1202 – ENGLISH PROFICIENCY

L-T-P-S : 0-0-4-0
Credits : 2
Contact Hours : 4
Pre-requisite : NIL

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Demonstrating different interpersonal skills for employability	PO 8	2
CO2	Distinguishing business essential skills	PO9	2
CO3	Classifying social media and corporate communication skills	PO 12	2
CO4	Applying analytical thinking skills	PO 12	3

Course Objective:

- To communicate with others in practical, business-oriented situations
- To express themselves in English with greater fluency, accuracy, and confidence
- To handle themselves in English in a variety of business contexts, from negotiating, to using the telephone, to making presentations, to socializing

Syllabus:

Job description- Advice on job applications – getting the right job- importance of doing a job interview -Launching and promoting a new product-Persuasive and negotiation skills -Types of emails: giving information, making an enquiry, answering enquiries -Marketing Report
Becoming an entrepreneur- buying a franchise- franchising start -up -presenting business idea- signaling parts of presentation - arranging business travel- business conferences and meetings- spending sales budget
Social media and business- introducing company using social media- staff survey- survey report- off-shoring and outsourcing- customer satisfaction and loyalty- communication with customers- corresponding with customers- business across cultures
Underlying assumptions, finding the conclusions, Argument strengthening, Argument weakening, finding the fallacies

Reference Books:

1. Business Benchmark Book- Upper Intermediate - 2nd edition Cambridge Press 2019.
2. Business Benchmark Book- Pre-Intermediate to Intermediate- 2nd edition Cambridge Press 2019.
3. Business Benchmark Book-Upper Intermediate: 2nd Edition Cambridge Press, 2019
4. Pillai, Sabina, et.al, Soft Skills and Employability Skills, New Delhi: CUP. 2018. Print.
5. Peterson, Reading Skill, New York: Peterson. 2007
6. Verbal and Non-Verbal Reasoning, R. S. Aggarwal, S Chand Publications.
7. R S Agarwal, S Chand, 'A modern approach to Logical reasoning'
8. GRE Barron's, Mc Graw Hills
9. Logical Reasoning, Edgar Thorpe, Pearson Publications

Web Links:

1. https://www.cambridgeenglish.org/
2. https://learnenglish.britishcouncil.org,
3. https://apps.apple.com/in/app/bec-from-cambridge/id1351207688
4. https://play.google.com/store/apps/details?id=com.liqvid.bec
5. https://www.cambridgeenglish.org/exams-and-tests/business-preliminary/exam-format/
6. https://www.cambridgeenglish.org/exams-and-tests/business-preliminary/preparation/
7. www.bbclearningenglish.com
8. www.indiabix.com
9. www.freshersworld.com
10. **Error! Hyperlink reference not valid.**
11. www.coolavenues.com
12. www.indiaedu.com/entrance-exams/cat.../books.html
13. www.mycatprep.com

22UC2103 – ESSENTIAL SKILLS FOR EMPLOYABILITY

L-T-P-S : 0-0-4-0
Credits : 2
Contact Hours : 4
Pre-requisite : NIL

Mapping of Course Outcomes with PO/PSO:

CO NO.	Course Outcome(CO)	PO/PSO	BTL
CO1	Developing basic grammar	PO2	2
CO2	Discovering and practicing functional grammar	PO2	2
CO3	Developing Intrapersonal skills.	PO5	2
CO4	Developing Speaking and Writing Skills	PO2	2

Course Objective:

1. To develop and illustrate basic and functional grammar
2. To demonstrate speaking, and writing skills
3. To apply interpersonal skills
4. To strengthen word powerTo develop comprehending skills

Syllabus:

COMPETENCY: Grammar
• Prepositions
• Tenses
• Voice
• Speech
• Sentence Improvement
COMPETENCY: Functional Grammar
• Spotting Errors
• Sentence Rearrangements
• 300-word list
Cloze Test
COMPETENCY:
• SWOC
• Self-awareness
• Attitude
• Self-Confidence
• Grooming
• Etiquettes
COMPETENCY: **Oral Communication Skills**
• Speaking from the script through JAM & Extempore

- Product & Process Description through JAM & Extempore
- Passage completion
- Paragraph & Essay writing

TEXTBOOKS:

1. Objective English for Competitive Examination by Hari Mohan Prasad and Uma Sinha.
McGraw Hill Education, 2017.
2. English Language Communication Skills, Cengage, 2014
3. Soft Skills and Professional Communication Skills – Francis Peter S.J. Tata MCGraw Hill Education Private Limited New Delhi 2012
4. Managerial Skills – K. Alex, S.Chand & Company Pvt. Ltd. New Delhi 2013

Reference Books:

R1. Soft Skills by Dr. Alex S CHAND Publications
R2. Objective English by Showarick Thrope, Pearson

Web Links:

www.indiabix.com
www.freshersworld.com
www.managementparadise.com
www.coolavenues.com
www.indiaedu.com/entrance-exams/cat.../books.html
www.mycatprep.com
www.bookboon.com

22UC2204 – CORPORATE READINESS SKILLS

L-T-P-S Structure :0-0-4-0
Credits :2
Contact Hours :4
Pre-Requisites **:** 22UC2103

Mapping of Course Outcomes with PO/PSO:

CO	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Extend word power for developing effective speaking and writing skills	12	2
CO2	Differentiate critical and general reading skills	12	2
CO3	Interpret interpersonal skills	12	2
CO4	Demonstrate necessary skills to be employable	12	2

SYLLABUS

Verbal Ability: Synonyms and Antonyms, Sentence Completion, Idioms & Phrases, One Word Substitutes, Analogies, Spellings, Selecting words, Sentence Formation

Reading Skills: **Reading Comprehension and Types of Questions, Critical Reading (CAT & GMAT models)**
Life Skills: Goal Setting, Team Building, Leadership, Time Management, Managing Stress, Work Ethics

Employability Skills: **Empathy, Assertiveness, Impression Management, Portfolio Management, Group Discussion, C V**

TEXTBOOKS:

1. Objective English for Competitive Examination by Hari Mohan Prasad and Uma Sinha. McGraw Hill Education, 2017.
2. English Language Communication Skills, Cengage, 2014
3. Soft Skills and Professional Communication Skills – Francis Peter S.J. Tata MCGraw Hill Education Private Limited New Delhi 2012
4. Managerial Skills – K. Alex, S.Chand & Company Pvt. Ltd. New Delhi 2013

REFERENCE BOOKS:

- R1. Soft Skills by Dr. Alex S CHAND Publications

- R2. Objective English by ShowarickThrope, Pearson

WEB REFERNCES/MOOCS:

www.indiabix.com
www.freshersworld.com
www.managementparadise.com
www.coolavenues.com
www.indiaedu.com/entrance-exams/cat.../books.html
www.mycatprep.com

22UC0010-UNIVERSAL HUMAN VALUES & PROFESSIONAL ETHICS

L-T-P-S : 2-0-0-2
Credits : 2
Prequisite : NIL

Course Outcomes(Cos)-Program Outcomes (Pos)-Blooms Taxonomy Levels(BTL) Mapping table

CO#	Course Outcome	PO/PSO	BTL
CO1	Realize the basic aspiration and understanding harmony in the human being. Understand the process of Self-exploration and able to differentiate between right and wrong. Realize the harmony in the self, and body.	PO8	1
CO2	Realize the purpose of family and understand about relationship and attain harmony in society	PO8	1
CO3	Realize ways to attain harmony in nature. Realize the root cause of the techno-genic maladies and able to identify the solution and understand harmony in the human being.	PO8	2
CO4	Realize the definitiveness of human conduct. Analyze the profession and his role in this existence.	PO8	2

Syllabus:

Introduction to Value Education: Understanding Value Education, Self-exploration as the Process for Value Education, Continuous Happiness and Prosperity - The Basic Human Aspirations, Right Understanding, Relationship and Physical Facilities, Happiness and Prosperity – Current Scenario, Method to fulfill the Basic Human Aspirations.

Harmony in the Human Being: Understanding the Human Being as Co-existence of Self ('I') and Body, Discriminating between the Needs of the Self and the Body, The Body as an Instrument of 'I', Understand Harmony in the Self ('I'), Harmony of the Self ('I') with the Body, Program to Ensure Sanyam and Svasthya.

Harmony in the Family and Society: Harmony in the Family - the Basic Unit of Human Interaction, Values in Human-to-Human Relationships, 'Trust' – the Foundational Value in Relationships, 'Respect' – as the Right Evaluation, Understand Harmony in the Society, Vision for the Universal Human Order.

Harmony in the Nature (Existence): Understand Harmony in the Nature, Interconnectedness, Self-regulation and Mutual Fulfillment among the Four Orders of Nature, Realizing 'Existence is Co-existence' at All Levels, The Holistic Perception of Harmony in Existence.

Implications of the Right Understanding – a Look at Professional Ethics: Natural Acceptance of Human Values, Definitiveness of (Ethical) Human Conduct, A Basis for Humanistic Education, Humanistic Constitution and Universal Human Order, Competence in Professional Ethics, Holistic Technologies, Production Systems and Management Models - Typical Case Studies, Strategies for Transition towards Value-based Life and Profession.

Text Books:

1. R R Gaur, R Sangal and G P Bagaria, "A Foundation Course in Human Values and Professional Ethics", 1st Edition, Excel Books.

22UC0007 – INDIAN HERITAGE AND CULTURE

L-T-P-S : 2-0-0-0
Credits : NIL
Contact Hours : 2
Pre-requisite : NIL

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	To familiarize with various aspects of the culture and heritage of India through ages.	PO1	1
CO2	To acquaint with the contributions of Indians in the areas of languages and literature, religion and philosophy	PO1	1
CO3	To understand the social structure and the spread of Indian culture abroad	PO1	1
CO4	To know the development of Science and Technology in India through ages and to appreciate the contributions of some of the great Indian scientists	PO1	1

Syllabus:

Introduction-Concept of Culture-Culture and Civilization-General Characteristics of Indian Culture-Importance of Culture-Unity in Diversity

History and Culture through the Ages – Fundamental Unity of Harappan and Vedic Culture – Jainism and Buddhism-Mauryan Period-Post-Mauryan Period-Gupta Period-Pallavas and Cholas

Advent of Islam in India-Islam and Sufism-Islamic Art and Architecture-Bhakti Movement-Vijayanagar Period-Art and Architecture and Literature

Rise of the West and its impact on India-Social and Religious reformers in the 18^{th} and 19^{th} centuries-Press and growth of modern Indian literature-Rise of Indian Cinema-Indian Independence

Reference Books:

1. Facets of Indian Culture- Spectrum Publications
2. Ancient India: National Council of Educational Research and Training
3. Medieval India: Part I & Part II: National Council of Educational Research and Training.
4. Modern India: National Council of Educational Research and Training.
5. An Advance History of India: R.C. Majumdar, H.C. Raychaudhuri&KalikinkarDatt: Macmillan India Ltd.
6. The Wonder that was India : A.L.Bhasham

22UC0008 – INDIAN CONSTITUTION

L-T-P-S : 2-0-0-0
Credits : NIL
Contact Hours : 2
Pre-requisite : NIL

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	To understand Constitutional development after Independence	PO12	2
CO2	To learn the fundamental features of the Indian Constitution	PO12	2
CO3	To get a brief idea of the powers and functions of Union and State Governments	PO12	2
CO4	To understand the basics of working of Indian Judiciary and the Election Commission	PO12	2

Syllabus:

Making of the Constitution: A brief analysis of National Movement. Constitutional development with reference to Government of India Act-1909,1919,1935 and Indian Independence Act-1947. The Constituent Assembly of India.

Basic features of the Indian Constitution: the Preamble, Fundamental Rights, Directive Principles of State Policy – Fundamental Duties

Government of the Union : The Union Executive – the President and the Vice-President – The Council of Ministers and the Prime Minister – Powers and functions, The Union legislature – The Parliament – The LokSabha and the RajyaSabha, Composition, powers and functions – the role of the Speaker.

Government of the State: The Governor – the Council of Ministers and the Chief Minister – Powers and Functions, The State Legislature – composition, powers and functions.

The Indian Judicial System: the Supreme Court and the High Courts – composition, Jurisdiction and functions, Judicial review, Judicial activism, Independence of Judiciary In India.

Election Commission: Role and Functioning, Chief Election Commissioner and Election Commissioners.

Reference Books:

1. Indian Polity' by Laxmikanth
2. Indian Administration' by SubhashKashyap
3. 'Indian Constitution' by D.D. Basu
4. 'Indian Administration' by Avasti and Avasti
5. 'Constitutional Law of India' by Seervai H.M.

22UC0009 – ECOLOGY AND ENVIRONMENT

L-T-P-S : 2-0-0-0
Credits : NIL
Contact Hours : 2
Pre-requisite : NIL

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand about basic concepts of Environment and Environmental Education	PO1	2
CO2	Understanding the importance of ecosystems and biodiversity.	PO3	2
CO3	Understanding the environmental pollution.	PO1	2
CO4	Understanding the solid waste management, disaster management and EIA process.	PO3	3

Syllabus:

The Multidisciplinary nature of Environmental Studies - Introduction to Environment, Definition, scope ,importance, Multidisciplinary nature of Environmental Studies, Need for public awareness. Institutions and people in Environment b)Natural Resources- Renewable and Non Renewable Resources Forest resources - Benefits, Deforestation, causes, effects and impacts, Afforestation programmes, Socio-forestry, Agro-forestry, Vanasamrakshana programmes,. Mining its impact on environment - mining, dams and their effects on forests and tribal people. Water resources-Distribution of surface and ground water, Aquifers, floods, drought, conflicts over water, dams, benefits and problems, Water conservation, rain water harvesting, watershed management, Cloud seeding Mineral resources- Use, exploitation, environmental effects. Food resources- Changes in agricultural methodologies, comparison between old and new methods of farming, Green Revolution, Environmental Impact Assessment of conversion of agricultural lands, effects of modern agriculture, Drip Irrigation, fertilizer, pesticide problems, Eutrophication, Vermi-compost, water logging, Blue baby syndrome. Energy resources - Growing energy needs, renewable and non renewable energy sources. Land resources-. Soil erosion- Importance of soil, Types of soil erosion, Causes and effects of soil erosion. How to control soil erosion. Role of an individual in conservation of natural resources. Ecosystems - Concept of an ecosystem, Structure and function of an ecosystem, Energy flow in the ecosystem, Ecological succession, Food chains, food webs and ecological pyramids. Types of ecosystem

Biodiversity and its Conservation- Introduction, Definition, Levels, Values of biodiversity, India as a mega diversity nation. Hotspots of biodiversity. Threats to biodiversity- Endangered and endemic species of India. Conservation of biodiversity- Assessment of Biodiversity and its impact on Environment

Environmental Pollution- Definition, Causes, effects, control measures of Air pollution, Water pollution, soil pollution, Marine pollution, Noise pollution, Thermal pollution, Nuclear hazards. Solid waste management. Electronic waste management, Biomedical waste management - Role of an individual in prevention of pollution. Disaster management–.Climate change, global warming, acid rain, ozone layer depletion

Environmental Legislation and objectives of Environment Protection Act, Air (Prevention and Control of Pollution) Act, Water (Prevention and control of Pollution) Act, Wildlife protection Act, Forest conservation Act, Biodiversity Act, Public awareness. Environmental Impact Assessment Process

Reference Books:

1. Introduction to Ecology, Paul Colinvaux, 1973, Wiley International Edition.
2. Fundamentals of Ecology, E.P. Odum, 1971, W.B.Saunders & Co.

Web Links:

1. https://nptel.ac.in/courses/120108005/module1/lecture1.pdf
2. https://nptel.ac.in/courses/104103020/module7/lec6/9.html

22UC0011-GENDER SENSITIZATION

L-T-P-S : 2-0-0-0
Credits : 2
Contact Hours : 2
Pre-requisite : NIL

Mapping of Course Outcomes to Program Outcomes: The students will be able to

CO No	Course outcome	PO	BTL
1	Students will have developed a better understanding of important issues related to gender in contemporary India	7	2
2	Students will be sensitized to basic dimensions of the biological, sociological, psychological and legal aspects of gender. This will be achieved through discussion of materials derived from research, facts, everyday life, literature and film	7	2
3	Students will attain a finer grasp of how gender discrimination works in our society and how to counter it.	7	2
4	Students will acquire insight into the gendered division of labour and its relation to politics and economics.	7	2

Syllabus:

UNDERSTANDING GENDER:

Socialization: Making Women, Making Men, Preparing for Womanhood, Growing up Male, First lessons in Caste, Different Masculinities.

GENDER AND BIOLOGY:

Missing Women: Sex Selection and Its Consequences, Declining Sex Ratio. Demographic Consequences. Gender Spectrum: Beyond the Binary Two or Many? Struggles with Discrimination.

GENDER AND LABOUR:

Housework: the Invisible Labour, Women's work: Its politics and Economics, Fact and Fiction. Unrecognized and Unaccounted work. Additional Reading: Wages and Conditions of Work.

ISSUES OF VIOLENCE:

Sexual Harassment: Say No! Sexual Harassment, not Eve-teasing- Coping with Everyday Harassment, Domestic Violence: Speaking Out, Is Home a Safe Place? -When Women Unite [Film]. Rebuilding Lives. Additional Reading: New Forums for Justice. Thinking about Sexual Violence.

Textbooks:

1. Suneetha, Uma Bhrugubanda, Duggirala Vasanta, Rama Melkote,Vasudha Nagaraj, Asma Rasheed, Gogu Shyamala, Deepa Sreenivas and Susie Tharu "Towards A World of Equals A Bilingual Textbook on Gender", Telugu Akademi, Hyderabad, 2015.

Reference Books:

1. Menon, Nivedita. Seeing like a Feminist. New Delhi: Zubaan-Penguin Books, 2012

BASIC SCIENCES

22MT1101 –MATHEMATICS FOR COMPUTING

L-T-P-S : 2-2-0-0
Credits : 4
Contact hours : 4
Pre-requisite : NIL

Mapping of Course Outcomes with PO/PSO:

CO No:	Course out come	PO	BTL
1	Model a system of equations for real world applications in engineering, physical and biological sciences, computer science, finance, economics and solve them through matrix algebra	**1**	**3**
2	Model basic and computational techniques on discrete structures like relations, orders, functions & FSM, Lattices, and propositional &predicate logic	**1**	**3**
3	Model real world structures and their related applications using advanced discrete structures like graphs and trees.	**1**	**3**
4	Model the given Statistical data for real world applications in Engineering science, Economics and Management.	**1**	**3**
5	Demonstrate the Aptitude and Reasoning skills (Tests in skilling hours)	**1**	**2**

SYLLABUS :

Linear Algebra (12 Hours)

Matrix Algebra: Introduction, Types of Matrices, Rank of matrix, Solutions of linear Equations by Gauss elimination and Gauss Seidel methods, Eigen values, Eigen vectors. Quadratic forms

Introduction to Discrete Structures & Discrete Computation: (12 Hours)

Relations: Closures of relations. Orders, Equivalence Relations, Functions, Finite-State Machines
Lattices: Partial order relation, Hesse Diagrams, Properties of Lattices and applications.
Logic and Proofs: Propositional Logic, Rules of Inferences, Applications of Propositional, Propositional
Equivalences, Predicates and Quantifiers, Predicate logic, Consequences, Introduction to proofs, Proof methods and strategy.
Counting Techniques: Permutations and Combinations Fibonacci series, Divide-and-Conquer Algorithms, Recursive definitions, Generating Functions. Solving Linear Recurrence Relations

Advanced Discrete Structures & Computation (12 Hours)

Graphs & Trees: Terminology, Types of Graphs, Bipartite graphs, Graph Isomorphism, Connectivity, Euler and Hamilton Paths, Shortest-Path, Planar Graphs, Trees, Tree Traversal Applications of trees, spanning trees and Minimal spanning trees

Modeling Statistical data for real world applications (12 Hours)

Axiomatic definitions of probability, addition rule and conditional probability, multiplication rule, total probability, Correlation, Regression and Curve fitting.

Skilling: {Tests in skilling hours} 2 hours per week [24 hours]

Arithmetic: (12 Hours)(Focus on Shakuntaladevi puzzles)

Foundations in Arithmetic: Numbers, Ratio, Proportion, Variation, Averages, Percentages, Profit & loss, Time & Distance, Time & Work.

Applications of Number theory: Fermat's theorem, Euclidean Algorithm. *Geometry:* Lines, Triangles, Quadrilaterals, Polygons, Practical applications of common solids, irregular solids and their application in various engineering problems.

Logic & Reasoning: (12 Hours))(Focus on Shakuntaladevi puzzles)

Sets and Venn diagrams Deductions, Logical Connectives, Linear and circular arrangements. Clocks, Calendars, Blood Relations, Cubes, Number and letter series, Coding and Decoding, Symbolic representations of given data, Binary Logic, Non-Verbal reasoning.

Textbooks:

1. John Bird, Basic Engineering Mathematics**,** Sixth edition, Taylor & Francis Ltd., 2017, UK.
2. Kenneth H Rosen, Discrete Mathematics and its Applications, Seventh edition, McGraw Hill, 2007, USA.
3. Linear Algebra and Its Applications, Gilbert Strang, Fourth Edition

Reference Books:

1. Advanced Engineering Mathematics 10th Edition, Erwin Kreyszig
2. R.E. Walpole, R.H. Myers, S.L. Myes, Keying Ye, Probability and Statistics for engineers and scientist, Ninth edition, Pearson publications, 2012, USA.
3. Mott, J.L., Kandel, A. and Baker, T.P., Discrete Mathematics for Computer Scientists and Mathematicians, Second edition, Prentice Hall India Pvt Ltd, 1986, India.
4. Tremblay J P and Manohar R, "Discrete Mathematical Structures with Applications to Computer Science", First edition, Tata McGraw Hill, 1975, India.
5. R. S. Agarwal, A Modern Approach to Verbal and Non-verbal Reasoning, S Chand Publications, 2018, New Delhi, India.

WEB REFERENCES/MOOCS:

1.https://www.youtube.com/watch?v=PmO_QdLrRZg

2.https://nptel.ac.in/noc/individual_course.php?id=noc18-cs53

3.https://www.khanacademy.org/partner-content/pixar/crowds/crowds2/v/combinatorics11

4.https://nptel.ac.in/courses/106106094/16

5.https://onlinecourses-archive.nptel.ac.in/noc18_cs53

22MT2102 – MATHEMATICS FOR ENGINEERS

Course code : 19MT2102
L-T-P-S : 2-1-0-0
Credits : 3
Contact Hours : 3
Pre-requisite : NIL

Mapping of Course Outcomes with PO/PSO:

CO No:	Course out come	PO	BTL
1	Apply differential and integral calculus to find maxima & minima of functions, evaluate the integrals and solve the differential equations.	**1**	**3**
2	Demonstrate the Fourier series and Laplace transforms.	**1**	**3**
3	Describe probability , Random Variables	**1**	**3**
4	Explain complex variables, analytic functions and introduction to stochastic process and Algebraic structures.	**1**	**3**

SYLLABUS :

***(A)Calculus*:**

(a) Differential and Integral Calculus: Taylor's series for function of two variables, Maxima and Minima for functions of two variables, Evaluation of double and triple integrals , Change of order of Integration, Change of Variables, in polar, cylindrical and spherical coordinates.

(b) Vector Calculus: Scalar and vector point functions, Gradient, Directional Derivative, Divergence and Curl, Evaluation of line integrals , Introduction to Greens and Stoke's theorems and their applications.

(c) Ordinary Differential Equations: Solution of first order equations and their Applications, Newton law of cooling, Growth and Decay, Solution of Second and higher order Differential equations .

(d) Partial Differential Equations: Formation of PDE, Solution of first order linear equations – Lagrange's method, Solution of second order PDE by separation of variables . Laplace's equation in two dimensions.

(B)Introduction to Advanced Matrix Algebra:

Decomposition, Complex Matrices

(C) Laplace Transforms: Laplace and Inverse Laplace transforms and their properties.

(D) Fourier Series: Definition, Dirchelt conditions, Fourier series for simple functions.

(E) Complex Variables : Complex functions- Exponential, Logarithmic and Trigonometric functions , Analytic function , Cauchy - Riemann equations , Introduction to Milne Thomson method .

(F) Probability and Random Variables: Probability , Addition, Multiplication and Baye's theorems. Random variables , Probability Distributions – Binomial, Poisson and Gaussian distributions, Introduction to Markov process.

(G) Algebraic Structures: Introduction to Structure of Algebras, Semi groups, Monoids and Groups, Homomorphism's, Normal subgroups and congruence Relations, Rings**.**

Text books:

1. Erwin Kreyszig, Advanced Engineering Mathematics, John Willey & Sons, 10th edition, 2010, New Delhi, India.

Reference Books:

1. R.E.Walpole, R.H.Myers, S.L.Myes, Keying Ye, Probability and Statistics for Engineers and Scientists, , Pearson's Publications , 9th edition, 2012, USA.

2. Mott, J.L., Kandel, A. and Baker, T.P., Discrete Mathematics for Computer Scientists and Mathematicians, Prentice Hall of India Private Ltd, 1986, India.

3. Tremblay J P and Manohar R, Discrete Mathematical Structures with Applications to Computer Science, Tata McGraw Hill publishers, 1st edition, 2001, India.

WEB REFERNCES/MOOCS:

1. https://www.maplesoft.com/applications/view.aspx?sid=1591&view=html
2. https://x-engineer.org/graduate-engineering/electronics/circuits/rl-circuit-detailed-mathematical-analysis/
3. http://www.ugrad.math.ubc.ca/coursedoc/math100/notes/diffeqs/cool.html
4. https://www.slideshare.net/mohammadimran85/solved-numerical-problems-of-fourier-series

22ME2209– NUMERICAL COMPUTATION FOR MECHANICAL ENGINEERS

L-T-P-S : 3-0-2-0
Credits : 4
Contact Hours : 5
Pre-requisite : NIL

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Apply various approximate methods to solve problems in structural mechanics and to provide simplicity involved in Finite Element Method	PO1-2	3
CO2	Apply Galerkin method for solving problems on heat transfer, torsion, and fluid flow	PO1-2	3
CO3	Analyze dynamic problems for longitudinal and transverse vibration of beam, and critical load estimation of columns	PO1-2	4
CO4	Analyze the experimental data using simple and useful methods of Statistics	PO1-2	4
CO5	Apply MATLAB programming to solve solid and fluid mechanics problems	PO1-3, PO5-3	3

Syllabus:

Various Methods of Analysis – Exact Method – Approximate Method (Variational Approach & Weighted Residual Method: Collocation method, Subdomain method, Least Square method, Galerkin method) - Finite Difference Method – Finite Element Formulation - Solution Techniques - Problems of axially loaded beams and beam bending.

Application to Scalar Problems – Governing equations for boundary value problems – Heat Transfer (one & two-dimensional steady state heat transfer problems) – Torsion of non-circular section – Fluid flow problem (Stream function approach & Potential function approach)

Dynamics and Stability Analysis – Governing Equations – Longitudinal Vibration – Bar of varying cross-section – Lateral Vibration – Stability of column

Statistical Analysis of Experimental Data - Characterizing Statistical Distributions – Representing Data – Measures of Central Tendency – Statistical Distribution Functions (Gaussian Distribution, Weibull Distribution) – Confidence Intervals for Predictions – Comparison of Means – Statistical Safety Factor – Statistical Conditioning of Data – Regression Analysis (linear regression – Multivariate Regression – Linear & Nonlinear Least-Squares Methods – Chi-square Analysis.

Lab Exercises

Covers elementary programming concepts, including variable types, data structures, and flow control. Provides an introduction to linear algebra and probability.

Numerical methods relevant to Mechanical Engineering, including approximation (interpolation, least squares, and statistical regression), integration, solution of linear and nonlinear equations, and ordinary differential equations.

Presents deterministic and probabilistic approaches. Uses examples from Mech.Engg, particularly from robotics, dynamics, and structural analysis.

Assignments require MATLAB programming

Text Books:

1. O.C. Zienkiewicz, "Finite Element Method", 3rd Edition, Tata McGraw-Hill, 2003.

2. R. Dhanraj and K. Prabhakaran Nair, "Finite Element Method", Oxford University Press, New Delhi, India, 2015.

3. Erwin Kreyszig, "Advanced Engineering Mathematics", John Willey & Sons, 10th Edition, New Delhi, India, 2010.

4. R.E. Walpole, R.H. Myers, S.L. Myes, Keying Ye, "Probability and Statistics for Engineers and Scientists, Pearson's Publications, 9th Edition, USA, 2012

1. Guttag, John. Introduction to Computation and Programming Using Python: With Application to Understanding Data. 2nd ed. MIT Press, 2016. ISBN: 978-0262529624.
2. Jake VanderPlas. Python Data Science Handbook: Essential Tools for Working with Data 1st Edition, O'Reilly Media, 2016. ISBN: 978-1491912058.

Reference Books:

1. Oliver Knill. Probability and Stochastic Processes with Applications.Overseas Press. 2009. ISBN : 978 – 8189938406.

22UC1103-DESIGN THINKING AND INNOVATION

L-T-P-S : 0-0-4-0
Credits : 2
Contact Hours : 4
Pre-requisite : NIL

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand the importance of Design thinking process for contextualized problems	PO2,PO6	2
CO2	Analyse, define, and ideate for solutions	PO9,PO3	4
CO3	Develop and test the prototype made	PO4,PO9	3
CO4	Explore the fundamentals of entrepreneurship skills for transforming the challenge into an opportunity	PO10,PO11	2

Syllabus:

Syllabus :Design thinking an overview, Design Thinking for Contextualized Problem-Solving: Problem Selection/Definition Need for Cultural Relevance (Time, Space, and Environment). Empathy: definition, Empathic research: framing interview questions, focus groups, procedure to conduct skilled interviews, Insights from Empathetic research, Define: Developing user personas, nuggets from insights, laying customer journey maps, POV statements and POV questions to define user needs. Ideate: Techniques to generate, shortlist and evaluate Ideas: Rapid Estimation form and Solution concept form. Prototyping and Testing: Products vs. Services, Rough Prototypes, Testing Techniques, User Experience High-Fidelity Prototypes Entrepreneurial Innovation: Innovation Management, Business Model Basics, Financial Estimation, Pitch Decks, IPR Considerations

Text Books :

1. David Lee: Design Thinking in Classroom. Ulysses Press: 2018
2. The Art of Innovation Lessons in Creativity from IDEO, America's Leading Design Firm by Tom Kelley : 2001

Reference Books :

1. Michael Lewrick, Patrick Link & Larry Leifer: The Design Thinking Play Book. Wiley Press: 2018

22PH1010 – MECHANICS

L-T-P-S : 3-1-0-0
Credits : 4
Contact Hours : 4
Pre-requisite : Nil

Mapping of Course Outcomes with PO/PSO:

CO NO	Course Outcome (CO)	PO/PSO	BTL
CO1	Apply the concept of forces, governing static equations and analyse planar system of forces.	PO1	3
CO2	Use analytical techniques for analysing forces in statically determinate structures.	PO1	4
CO3	Apply the concepts of planar and non-planar system of parallel forces and estimate the moment of inertia for lamina and material bodies.	PO5	3
CO4	Apply fundamental concepts of kinematics and kinetics of particles to solve simple practical problems.	PO5	3

Syllabus:

TWO-DIMENSIONAL FORCE SYSTEMS: Introduction, Basic concepts, Laws of motion, Principle of Transmissibility of forces, Resultant of a force system, force laws, Resultant of two dimensional concurrent and Non-Concurrent Force systems, Free body diagrams, Applications. Equilibrium of Rigid bodies– Equilibrium and Equations of Equilibrium, Lami‘s theorem, Type of supports and their reactions, Moments and couples, Varignon‘s theorem, Resultant moment and applications.

SPATIAL FORCE SYSTEM & TRUSSES: Spatial force systems – Forces in space, resultant and equilibrium of spatial force system. Truss Analysis-Trusses -Assumptions involved in the Method of joints and sections.

FRICTION AND PROPERTIES OF AREAS: Friction: Introduction, Laws of Coulomb Friction, Equilibrium of Bodies involving Dry-friction, Applications-ladder friction, wedge friction.
CENTRIOD AND MOMENT OF INERTIA: Centroid, Centre of gravity, Moment of inertia - Area and Mass- polar moment of inertia, Parallel axis theorem.

KINEMATICS OF RIGID BODY: Introduction, Plane Motion of Rigid Body, Velocity and Acceleration under Translation and Rotational motion. Virtual Work: Introduction - Principle of virtual work - Equilibrium of ideal systems.
KINETICS OF RIGID BODY: Introduction, Force, Mass and Acceleration, Work and Energy, Impulse and Momentum, D-Alembert’s Principles and Dynamic Equilibrium.

TEXT BOOKS:

1. Stephen Timoshenko, D. Young, J Rao, “Engineering Mechanics” Revised Fourth Edition (in SI Units) (special Indian Edition), Tata McGraw Hill.

2. Engineering Mechanics: Statics and Dynamics by A K Tayal, Umesh publications.

3. Engineering Mechanics: Statics and Dynamics by R C Hibbeler, Pearson.

REFERENCE BOOKS:

1. Irving H. Shames “Engineering Mechanics”, Prentice-Hall.

2. F. P. Beer and E.R. Johnston “Vector Mechanics for Engineers (in SI units) Statics & Dynamics” – Mc Graw Hill Publications.

3. Engineering Mechanics (Statics) by J L Meriam and L G Kraige, Wiley student edition.

22CY1001 - ENGINEERING CHEMISTRY

L-T-P-S : 3-0-2-0
Credits : 4
Contact Hours : 5
Pre-requisite : Nil

Mapping of Course Outcomes with PO/PSO:

CO #	CO	PO/PSO	BTL
CO1	Predict potential complications from combining various chemicals or metals in an engineering setting	PO-1,PO-3,PO-7	2
CO2	Discuss fundamental aspects of electrochemistry and materials science relevant to corrosion phenomena	PO-1,PO-3	2
CO3	Examine water quality and select appropriate purification technique for intended problem	PO-1,PO-7	2
CO4	Explain the role of chemical kinetics in the formation and destruction of ozone in the atmosphere and predict the connection between molecular behavior and observable physical properties.	PO-1,PO-7	2
CO5	An ability to analyze and generate experimental skills	PO-1,PO-4	3

SYLLABUS:

Electrochemistry: Single electrode potential and its measurement, Electrochemical cells, EMF series, Nernst equation, Cell emf measurement, Reversible and irreversible cells, Concentration cells, Reference electrodes-Determination of pH using glass electrode. Gas Sensors: Capacitance Manometer and Mass Spectrometer. *Batteries:* Chemistry, construction and engineering aspects of Primary (mercury battery) and secondary (lead-Acid cell, Ni-Metal hydride cell, Lithium cells) and fuel cells– Hydrogen–Oxygen fuel cell, advantages of fuel cell; *Energy and Chemistry***:** Energy Use and the World Economy, Defining Energy, Energy Transformation and Conservation of Energy, Heat Capacity and Calorimetry. Enthalpy, Hess's Law and Heats of Reaction, Energy and Stoichiometry.

CORROSION & ITS CONTROL: Causes and different types of corrosion and effects of corrosion. Theories of corrosion– Chemical, Electrochemical corrosion, Pitting corrosion, stress corrosion, Galvanic corrosion. Factors affecting corrosion– Nature of metal, galvanic series, over voltage, purity of metal, nature of oxide film, nature of corrosion product. Nature of environment- effect of temperature, effect of pH, Humidity, effect of oxidant. Cathodic protection, sacrificial anode, impressed current cathode, electroplating**:**

WATER Technology: Introduction, *Hardness:* Causes, expression of hardness – units – types of hardness, estimation of temporary and permanent hardness of water, numerical problems. Alkalinity and estimation of alkalinity of water, numerical problems. *Boiler troubles* – Scale & sludge formation, caustic embrittlement, Boiler corrosion, priming & foaming. Softening of water: Internal and external treatments -Lime soda, Ion exchange process. Desalination-reverse osmosis and electro dialysis:Chemical Kinetics: Ozone Depletion, Rates of Chemical Reactions, Rate Laws and the

Concentration Dependence of Rates, Integrated Rate Laws, Temperature and Kinetics, Reaction Mechanisms, Catalysis, insight into Troposphere Ozone.

Molecules and Materials: polymers- Types of polymerization-Mechanisms, Plastics – Thermoplastic resins and thermosetting resins - Preparation, properties and engineering applications of: polyethylene, PVC, Teflon, Bakelite, Urea Formaldehyde. *Conducting Polymers:* Polyacetylene, polyaniline, conduction, doping and applications. Carbon nano tubes and Applications.

Text Books:

1. Engineering Chemistry, Jain & Jain, Dhanpat Rai Publishing Company. New Delhi.
2. Engineering Chemistry, O G Palanna, The Tata McGraw Hill, New Delhi.

Reference Books:

1. Chemistry in Engineering and Technology, Volume 2, J C Kuriacose & J Rajaram, Tata McGraw Hill, New Delhi.
2. Chemistry for Engineers Rajesh Agnihotri, Wiley, New Delhi.
3. Engineering Chemistry, B. Sivasankar, The Tata McGraw Hill, New Delhi.
4. A text book of Engineering Chemistry, Shashi Chawla, Dhanpat Rai & Co. New Delhi.
5. Engineering Chemistry, C Parameswara Murthy, C V Agarwal and Andra Naidu, B S Publications, Hyderabad.
6. Engineering Chemistry, Shikha Agarwal, Cambridge University Press.

Web References:

1. http://www.chem1.com/acad/webtext/elchem/
2. https://nptel.ac.in/downloads/122101001/

https://www2.chemistry.msu.edu/faculty/reusch/virttxtjml/polymers.htm

22UC3105 - PROBLEM SOLVING SKILLS – 1

L-T-P-S Structure :**0-0-2-2**

Credits : **1.5**
Contact Hours :4
Pre-Requisites **:**Nil

Mapping of Course Outcomes (CO) to Program outcomes:

CO	Course Outcomes	PO	BTL
CO 1	Apply the concepts of mathematical principles besides logic and identifying certain basic mathematical formulae to solve these kinds of problems	12	3
CO 2	Formulate the concepts of mathematical principles of equations that contain the data related to real life situations which requires basic logic to analyze	12	2
CO 3	Solve concepts of Venn diagrams and number patterns and illustrate logic behind connectives, series, and analogies respectively	12	3
CO 4	Differentiate assumptions and arguments in critical reasoning	12	2

Syllabus:

Numbers, Divisibility, Decimal Fractions, LCM & HCF, Simplification,Sequence, Series & Progressions, Linear Algebra, Quadratic Equations & Inequalities, Theory of Equations. Sets, Relations & Functions, Surds & Indices, Logarithms.

Simple Equations, Problem on Ages, Ratio & Proportion, Variation& Partnership, Percentages, Profit, Loss& Discounts, Simple & Compound Interest, Averages & Allegations or Mixtures.

Number& letter series,Number, letter & word Analogy,Odd man out,coding & decoding, Cubes & Dice, Logical Venn Diagrams.

Syllogism,Statements & conclusions,statements & Arguments(Critical Reasoning),statements & Assumptions,logical connectives,Binary logic.

TEXTBOOKS:

1. Quantitative Aptitude by R.S. Agarwal, SCHAND Publications.
2. A Modern Approach to Verbal Reasoning by R.S. Agarwal, SCHAND Publications.
3. Logical Reasoning, Arun Sharma, McGraw Hill.

REFERENCE BOOKS:

R1. Quantitative Aptitude Quantum CAT by Sarvesh K Verma, Arihant Publications.
R2. Quantitative Aptitude for CAT by Arun Sharma, Mc Graw Hill Education.
R3. Analytical & Logical Reasoning, Peeyush Bhardwaj, Arihant Publications.

Web References:

- www.freshersworld.com
- www.managementparadise.com
- www.coolavenues.com
- www.indiaedu.com/entrance-exams/cat.../books.html
- www.mycatprep.com

22UC3206 - PROBLEM SOLVING SKILLS - II

L-T-P-S Structure :**0-0-2-2**
Credits : **1.5**
Contact Hours :4
Pre-Requisite **:**21UC3105

Mapping of Course Outcomes (CO) to Program outcomes:

CO	Course Outcomes	PO	BTL
CO1	Implement problem solving ability through analyzing the given data and formulate solutions for real world problems based on time, travel, and wages	12	3
CO2	Determine the fundamental concepts of areas, volumes and derive solutions using simple mathematical principles besides interpreting the data through smart tricks to check the number analytics	12	2
CO3	Estimate inductive reasoning, to categorize the rules-set from a given list of observations and relate them to predict the conclusions according to the given conditions	12	2
CO4	Integrate verbal and non-verbal reasoning and to identify the logic behind the given arrangement based on the given conditions to bring out the possible outcome	12	3

Syllabus

Time & Work, Chain Rule, Pipes & Cisterns, Time, Speed &Distance, Problems on Trains, Boats & Streams, Races & games, Permutations & Combinations, Combinatorics, Probability

Areas & Perimeters, Mensuration, Trigonometry, Heights & Distances, Geometry, Coordinate Geometry, Data Interpretation, Data Sufficiency, Statistics, Simplification, Crypt arithmetic

Blood Relations, Directions, clocks, calendars, Alphabet Test, Number, ranking & Time sequence test,Seating Arrangements,Mathematical Operations, Data Sufficiency, Nonverbal - series, analogy, classification

Input & Output, Assertion and reason , dot situation. embedded figures, figure matrix, mirror and water images, paper cutting, paper folding pattern completion, rule detection, flowcharts, Puzzles, Sudoku.

TEXTBOOKS:

1. Quantitative Aptitude by R.S. Agarwal, SCHAND Publications.
2. A Modern Approach to Verbal Reasoning by R.S. Agarwal, SCHAND Publications.
3. Logical Reasoning, Arun Sharma, McGraw Hill.

REFERENCE BOOKS:

R1. Quantitative Aptitude Quantum CAT by Sarvesh K Verma, Arihant Publications.
R2. Quantitative Aptitude for CAT by Arun Sharma, Mc Graw Hill Education.
R3. Analytical & Logical Reasoning, Peeyush Bhardwaj, Arihant Publications.

Web References:

- www.freshersworld.com
- www.managementparadise.com
- www.coolavenues.com
- www.indiaedu.com/entrance-exams/cat.../books.html
- www.mycatprep.com

ENGINEERING SCIENCES

22SC1101 – COMPUTATIONAL THINKING FOR STRUCTURED DESIGN

L-T-P-S : 2-0-2-4
Credits : 4
Contact Hours : 8
Pre-requisite : NIL

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Design Basic and Complex Building Blocks for real world problems using structured programming paradigm.	PO1,PO2	3
CO2	Translate computational thinking into Logic Design for Solving real world problems.	PO1,PO2	3
CO3	Apply and Analyse CRUD operations on Basic Data Structures using Asymptotic Notations.	PO1,PO2	4
CO4	Apply and Analyse CRUD operations on Linear Data Structures using Asymptotic Notations.	PO1, PO2	4
CO5	Apply the structured programming paradigm with logic building skills on Basic and Linear Data Structures for solving real world problems.	PO1,PO2	3

Syllabus:

Structured Programming Paradigm: Problem Solving Approach, Algorithms and Algorithm Analysis, Program Development Steps, Structure of C Program, Pre-Processor Directives,
Design of Building Blocks for solving real world problems: Modularization: Functions, Scope of Variables and Storage classes.
Data Types: Primitive, Extended and Derived Including Pointers,
Operators: Types of operators, Precedence, Associativity.
User I/O: Formatted I/O, Command line arguments, Redirecting I/O: Files and File Operations.
Logic Design for Computational Thinking:
Control Flow Statements:
Decision making using conditional statements, Definite and indefinite Iterative statements.
Recursion, logic building using complex building blocks.
CRUD operations on Basic Data Structures:
Basic Data Structure: Arrays, 2-D Arrays, Dynamic Memory Allocation
Searching: Linear Search and Binary Search
Sorting: Bubble Sort
CRUD operations on Linear Data Structures: Stacks, Queues and Single Linked List. Introduction to Trees.

Text Books:

1. Brian W. Kernighan, Dennis M. Ritchie, "The C Programming Language: ANSI C Version", 2/e, Prentice-Hall/Pearson Education-2005.
2. E. Balagurusamy, **"**Programming in ANSI C" 4th ed.,Tata McGraw-Hill Education, 2008.
3. R. F. Gilberg, B. A. Forouzan, "Data Structures", 2nd Edition, Thomson India Edition-2005.

Reference Books:

1. Mark Allen weiss, Data Structures and Algorithm Analysis in C, 2008, Third Edition, Pearson Education.
2. Horowitz, Sahni, Anderson Freed, "Fundamentals of Data structures in C", 2nd Edition-2007.
3. Robert Kruse, C. L. Tondo, Bruce Leung, Shashi Mogalla, "Data structures and Program Design in C", 4th Edition-2007.
4. C for Engineers and Scientists – An Interpretive Approach by Harry H. Cheng, Mc Graw Hill International Edition-2010.
5. Jeri R. Hanly, Elliot B. Koffman, "Problem Solving and Program Design in C", 7/e, Pearson Education-2004.
6. Jean Paul Trembly Paul G.Sorenson, "An Introduction to Data Structures with applications", 2nd Edition.

Web References / MOOCS:

- www.hackerrank.com
- www.codechef.com
- www.spoj.com

Independent Learning:

1. Computational Thinking with Beginning C Programming
https://www.coursera.org/specializations/computational-thinking-c-programming
2. CISCO NetAcad Course
https://www.netacad.com/courses/programming/cla-programming-c

22ME1103 - DESIGN TOOLS WORKSHOP -I

L-T-P-S : 0-0-4-0
Credits : 2
Contact Hours : 4
Pre-requisite : NIL

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Practice design thinking by developing artistic skills, Visualize and complete his/her innovative design by final drafting using 3D modeling	PO-3	3
CO2	Understand the concept of web page, web browser, web server, and able to create Static webpages	PO-5	3
CO3	Understand the concept of report writing using a markup language Latex	PO-5	3
CO4	Understand the concept of data visualization and creating data visualization dashboards, Understand the basic concept of VR/AR.	PO-5	3

Course Objectives:

The primary objective of this course is to immerse students into the world of innovation as a systematic process of tackling relevant business and/or social problems. To provide a social and thinking space for the recognition of innovation challenges and the design of creative solutions. An innovation new ventures, value propositions, new products or services.

Syllabus:

Introduction to Design tools: Introduction to design tools course, its objective, advantages
3D Modeling: - Conceptual Design, 2D Sketches to 3D Solid Model using AUTODESK FUSION 360.
HTML: Introduction to web browser and URL, Introduction to HTML, Creating a simple HTML page, HTML documents, Concept of tags, Basic structure of HTML document, Head, Body, Paragraph creation, line breaks, text, list, tables, Hyperlinks and images.
HTML5: Basic of HTML5, Special features of HTML5, Canvas, audio, video, Geo location, drag and drop.
CSS: Concept of CSS, Need of CSS, Creating style sheet, CSS properties, CSS styling (Background, text, format, controlling fonts), Styling with lists and tables, CSS Ids and class, CSS color, Creating page layouts and site design.
Data Visualization: Introduction to data visualization, Data, types, Importance of data visualization, Different tools for visualization and comparisons in brief. Excel data explanation, Creation of column Chart, stacked bar chart and Heat map, Creation of excel dashboard. Creation of Dashboards in Power BI. Creation of bar charts, date tables and pie charts in Power BI, creating slicers and maps in power BI.

Latex Report Writing: Understanding Latex compilation, Basic syntax, Writing equations, Tables, Figures handling, List of figures, List of tables, Generating index. Applications: Writing resume, Writing project reports.

Virtual Reality & Augmented Reality: Introduction to Virtual reality, Virtual 360 Environments, Creating basic 360 Virtual frame. Introduction to Augmented reality, Different types of AR, Platforms to create AR interfaces.

Text Books:

1. "Complete Design Thinking Guide for Successful Professionals" by Daniel Ling
2. "Rapid Prototyping: Principles and Applications by Chua C.K., Leong and Lim. C.S, 2nd Edition, World Scientific.
3. Learn HTML & CSS by John Duckett.
4. HTML5 and CSS3 All-in-One for Dummies
5. Mastering Microsoft Power BI Expert techniques for effective data analytics and business intelligence by Brett Powell
6. LaTeX Tutorials: A Primer by Indian TeX Users Group by Indian TeX Users Group (https://www.tug.org/twg/mactex/tutorials/ltxprimer-1.0.pdf)

Web Links:

1. https://www.coursera.org/learn/3d-model-creation-fusion-360
2. https://www.coursera.org/learn/html/home/welcome
3. https://www.udemy.com/course/become-a-good-latex-user-to-create-professional-documents/
4. https://www.udemy.com/course/microsoft-power-bi-latest-2020-beginner-to-expert-modules

22SC1209-DESIGN TOOLS WORKSHOP-II

L-T-P-S: 0-0-4-0
Credits: 2
Prerequisite: Nil
Course Outcomes (Cos) – Program Outcomes (Pos) – Blooms Taxonomy Levels (BTL) Mapping Table:

CO#	Course Outcome (CO)	PO/PSO	BTL
CO1	Practice the design ideology by 3D printing, 3D scanning techniques	PO-3	2
CO2	Visualize the design ideology by incorporating VR technique and VR technology, Visualize and present his design idea by applying AR technique and Hologram	PSO2, PO-5	3
CO3	Practice of PCB technology	PO-4	2
CO4	Practice of Arduino based skill with different interfaces	PO-4	2

Syllabus:

Design Thinking in 3D Printing Technology, Photogrammetry.

Introduction to 3D printing, Part Model 3D printing through FDM process, Assembly Model 3D printing through FDM process. Introduction to Photogrammetry, Photogrammetry by 3D scanning technology.

Virtual Reality: Hardware and History, VR Applications, Psychology of VR: the three illusions, challenges in virtual reality, Future of Embodiment in VR, Realism, Graphics, Real-Time 3D Graphics in Games, Basic Concepts in 3D Computer Graphics, Realism Animation, Navigation, Nausea.

Room Scale VR, Holography, Mirror Reality.

Setting up room scale VR, Simulation of virtual environment, Stereoscopic Vision, Perspective, Interference and Diffraction, Laser Viewable Holograms, Real and Virtual Images, Introduction to mirror reality.

Augmented Reality: Augmented Reality, characteristics of AR systems and main components of an AR architecture, Augmented Reality with Geolocation, Customizing an augmented reality game.

Arduino: Interfacing with display, sensors and actuators.

Interfacing of LED with Arduino, Interfacing of LED with push button with Arduino, Interfacing of temperature sensor with Arduino, Interfacing of LCD to display data with Arduino, Interfacing of DC motor**.**

Reference Books:

1. "Rapid Prototyping: Principles and Applications" by Chua C.K., Leong and Lim. C.S, 2nd Edition, World Scientific.
2. Creating Augmented and Virtual Realities: Theory and Practice for Next-Generation Spatial Computing, Erin Pangilinan, Steve Lukas, Vasanth Mohan
3. "Augmented Reality and Virtual reality" by Timothy Jung, M.Claudia Tom Dieck, Springer.
4. Holography: Principles and Applications (Series in Optics and Optoelectronics), by Raymond K. Kostuk
5. "Programming Arduino Next Steps: Going Further with Sketches- by Simon Monk"

Web Links:

1. https://www.coursera.org/learn/3d-printing-software
2. https://www.coursera.org/learn/ar
3. https://www.coursera.org/specializations/unity-xr
4. https://www.coursera.org/lecture/xr-introduction/the-vr-platform-landscape-room-scale-vr-Lvf8s

22SC1202 – DESIGN OF DATA STRUCTURES

L-T-P-S : 3-0-2-4
Credits : 5
Contact Hours : 9
Pre-requisite : 22SC1101

Mapping of Course Outcomes with PO/PSO:

CO#.	Course Outcome	PO/PSO	BTL
CO1	Apply measures of efficiency to algorithms and Compare various linear data structures like Stack ADT, Queue ADT, Linked lists.	PO1, PO3	3
CO2	Analyze and compare linear data structures and analyze different searching and hashing techniques	PO1, PO3	4
CO3	Analyze and compare various non – linear data structures like Trees and Graphs	PO1, PO3	4
CO4	Analyze and compare various sorting algorithms, to select from a range of possible options, to provide justification for that selection, and to implement the algorithm in a particular context.	PO1, PO3	4
CO5	Execute lab experiments and develop a small project along with his/her team members.	PO1, PO3	4

Syllabus:

Algorithm Analysis: Mathematical Background, Model, Analyze, Running Time Calculations, Lists**.**
Stacks and Queues: Abstract Data Types (ADTs), The List ADT, The Stack ADT, The Queue ADT.
Trees: Preliminaries, Binary Trees, The Search Tree ADT—Binary Search Trees, AVL Trees, Splay Trees, Tree Traversals (Revisited), B-Trees, Red black trees
Hashing: General Idea, Hash Function, Separate Chaining, Hash Tables without Linked Lists, Rehashing, Hash Tables in the Standard Library, Extendible Hashing.
Priority Queues (Heaps): Model, Simple Implementations, Binary Heap, Applications of Priority Queues.
Sorting: Preliminaries, Insertion Sort, A Lower Bound for Simple Sorting Algorithms, Shell sort, Heap sort, Merge sort, Quick sort, Indirect Sorting, A General Lower Bound for Sorting, Bucket Sort, External Sorting.

Text Books:

1. Mark Allen Weiss, Data Structures and Algorithm Analysis in C, 2010 , Second Edition, Pearson Education.
2. Ellis Horowitz, Fundamentals of Data Structures in C: Second Edition, 2015

Reference Books:

1. A.V.Aho, J. E. Hopcroft, and J. D. Ullman, “Data Structures And Algorithms”, Pearson Education, First Edition Reprint 2003.
2. Horowitz, Sahni, Anderson Freed, “Fundamentals of datastructures in C” , Second Edition-2007.

22ME1002 – ENGINEERING GRAPHICS & 2D MODELLING

L-T-P-S : 1-0-4-0
Credits : 3
Contact Hours : 5
Pre-requisite : NIL

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome (CO)	PO	PSO	BTL
CO1	Model Engineering Curves in engineering Practice, Conic sections and special curves, scales both manually and using computer aided design tool (CAD).	PO1,PO5	-	2
CO2	Project points, lines and planes in first angle third angle both manually and using CAD.	PO1, PO5	-	3
CO3	Project solids and generate the sectional views of solids, development of surfaces of regular solids both manually and using CAD.	PO1, PO5	-	3
CO4	Convert orthographic projections to create isometric view and isometric view to orthographic projection both manually and using CAD.	PO5	PSO1	3

Syllabus:

Introduction to Engineering Drawing: Principles of Engineering Graphics and their significance – Drawing Instruments and their Use- Conventions in Drawing – Lettering – Conic Sections: Ellipse, Parabola, Hyperbola and Rectangular Hyperbola – oblong, concentric method. Special Curves: Cycloid, Epicycloids, Hypocycloid, and Involutes. Scales: Plain and Vernier scales.

Projection of Lines, points and Projections of Planes: First and Third Angle Projections of Points and Lines inclined to planes, True lengths, traces. Constructions, Projections of regular planes inclined to both planes.

Projections of Solids and Developments of surfaces: Projections of Regular solids inclined to one plane. Sections and Sectional Views: Right Regular Solids - Prism, Cylinder, Pyramid, Cone.Surface development of right regular solids – Prisms, Cylinder, Pyramid cone and their parts.

Orthographic Projection in First Angle Projection and Isometric Projections: Principles of Orthographic Projections- conventions - Principles of Isometric Projection- Isometric Scale- Isometric view conventions- Isometric View of Lines, Plane Figures, and simple problems. Transformation of Projections: Conversion of Isometric Views to Orthographic Views – Conventions.

Text Books:

1. Engineering Drawing, N.D.Bhat/ Charotar
2. Engineering Drawing , N.S.Parthasarathy, VelaMurali
3. Machine drawing- N.D.Bhatt., published by R.C. Patel Charotar Book Stall TulshiSadan, Station Road, Anand, India

Reference Books:

1. Shah, M.B. & Rana B.C. (2008), Engineering Drawing and Computer Graphics, Pearson Education
2. Agrawal B. &Agrawal C. M. (2012), Engineering Graphics, TMH Publication.
3. Narayana, K.L. & P Kannaiah (2008), Text book on Engineering Drawing,Scitech Publishers(Corresponding set of) CAD Software Theory and User Manuals
4. Machine Drawing by / Bhattacharyya / Oxford
5. Machine Drawing with Auto CAD / GouthamPohit, GoutamGhosh / Pearson

MOOCS/Web Links:

1. https://nptel.ac.in/courses/112103019/
2. https://academy.autodesk.com/authenticated-home-user
3. https://www.youtube.com/channel/UCamtopKcVk176djUP_rbA-A
4. https://web.iitd.ac.in/~achawla/public_html/201/lectures/sp46.pdf
5. https://opac.vimaru.edu.vn/edata/EBook/Engineering%20drawing%20third%20edition.pdf.
6. https://www.sciencedirect.com/book/9780080108391/engineering-drawing-from-thebeginning.
7. https://gptcadoor.org/assets/downloads/3ckcwmvwfu0hyqq.ppt
8. https://www.ucvts.tec.nj.us/cms/lib/NJ03001805/Centricity/Domain/611/Lesson%201%20Intro%20to%20Drawing.pdf

22ME2104 – 3D MODELING AND PHYSICAL PROTOTYPING (WORKSHOP & 3D MODELLING S/W)

L-T-P-S : 0-0-4-0
Credits : 2
Contact Hours : 4
Pre-requisite : 22ME1002

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Develop 3D modeling and assembling of machine elements	PO1	3
CO2	Develop and interpret production drawing for various machine elements	PO1, PO3	3
CO3	Prepare different components using Carpentry, Tin-smithy trade and apply basic electrical engineering knowledge for house wiring practice.	PO1, PO3	3
CO4	Prepare different components using various manufacturing techniques and perform various machining operations.	PO1, PO3	3

Course Objective:

This course focuses on both traditional drafting techniques and computer aided drafting. Further, the course aims at enabling the students to understand and apply national and international standards while drawing machine component, and familiarize them in drawing various machine components, drafting the assembly and part drawings of machine components. Also, to familiarize with the procedures of basic manufacturing processes through hands on practice on the use of various hand tools and equipment. The course will make the student to demonstrate the abilities of preparing simple jobs on the shop floor and developing skills related to the mechanical operations needed for the industry."

Syllabus:

Review: Orthographic projection, missing lines, Interpolation of views and sectioning
Symbols of Machine, elements and welded joints.
Specification of materials: Engineering materials, code designation of steels, copper, and aluminium and its alloys.
Limits, tolerances and fits: Introduction, limit systems, tolerance, fits drawing exercises.
Surface roughness: Introduction, surface roughness, machining symbols, identification of surface roughness drawing exercises.
Part and assembly drawing: Introduction, assembly drawing of stuffing box, steam engine cross head, air valve, Lathe tailstock, gate valve, screw jack, connecting rods, spark plug, tool post, safety Valves etc. Drawing exercises.
Production drawing: Introduction to developing and reading of production drawing of simple machine elements like helical gear, bevel gear, flange, pinion shaft, connecting rod, crank shaft, belt pulley, piston details etc, idea about tool drawing.
Computer aided drawing: Introduction, input, output devices, introduction to drafting software like Creo/ Solidworks, basic commands and development of simple 2D and 3D drawings.

Carpentry (simple exercise in wood working, pattern making)
Fitting operations & power tools.

Electrical &Electronics
Sheet metal working, Welding (arc welding & gas welding and gas cutting), brazing, Plastic moulding, glass cutting.
Manufacturing Methods: casting, forming, machining, joining, advanced manufacturing Methods. CNC machining, Additive manufacturing.

Reference Books:

1. Hajra Choudhury S.K., Hajra Choudhury A.K. and Nirjhar Roy S.K., "Elements of Workshop Technology", Vol. I 2008 and Vol. II 2010, Media promoters and publishers private limited, Mumbai.
2. Kalpakjian S. And Steven S. Schmid, "Manufacturing Engineering and Technology", 4th edition, Pearson Education India Edition, 2002.
3. Gowri P. Hariharan and A. Suresh Babu, "Manufacturing Technology – I", Pearson Education, 2008.
4. Roy A. Lindberg, "Processes and Materials of Manufacture", 4th edition, Prentice Hall India, 1998.
5. Rao P.N., "Manufacturing Technology", Vol. I and Vol. II, Tata McGrawHill House, 2017.
6. Narayana "Machine drawing", New Age International
7. K.L.Narayana and P.Kannaiah "Production drawing", New Age International
8. Bhatt N.D "Machine drawing", Charotar

22EE2205 – CIRCUITS AND ELECTRONICS

L-T-P-S : 3-0-2-0
Credits : 4
Contact Hours : 5
Pre-requisite : NIL

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand the Basic of Electrical network elements	PO1, PO5	2
CO2	Understand the behavior of semiconductor switches and its applications	PO1, PO5	2
CO3	Apply Time & frequency domain analysis of first & second order networks	PO1, PO5	3
CO4	Understand the Applications of Analog & Digital circuits	PO1, PO5	2

Syllabus:

Fundamentals of the lumped circuit abstraction.Resistive elements and networks, independent and dependent sources.

Switches and MOS devices, digital abstraction, amplifiers, and energy storage elements.

Dynamics of first- and second-order networks; design in the time and frequency domains;

Analog and digital circuits and applications.

Text Books:

1. John Bird, Electrical Circuit Theory and Technology, Sixth edition, Newnes (Elsevier) publications, 2017.
2. Electric Circuits – J. Edminister and M.Nahvi – Schaum's Outlines,

Reference Books:

1. Network Analysis by ME Van Valkenburg, Prentice Hall of India, 3rd Edition, 2000.
2. Jacob Millman, Christor. C W. H. Hayt, J.E. Kimmerly, "Engineering circuit analysis", 8th Edition, Tata Mc-Graw Hill, 2014.

22ME2105 - THERMODYNAMICS

L-T-P-S : 3-0-0-0
Credits : 3
Contact Hours : 3
Pre-requisite : NIL

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Examine different thermodynamic terms and distinguish between micro & macroscopic approaches, process & change of state, reversible & irreversible process.	PO1-2	2
CO2	Apply first law of thermodynamics to various flow and non-flow processes.	PO1-3	3
CO3	Apply second law of thermodynamics and principle of entropy to Engineering Devices.	PO1-2	3
CO4	Analyze the performance of different air standard cycles and different psychrometric processes.	PO2-3	3

Syllabus:

Fundamental Concepts and Definitions: Thermodynamic system and control volume, macroscopic and microscopic points of view, thermodynamic properties, processes, state, path, cycle, thermodynamic equilibrium and quasi-static process. Reversible and irreversible processes, zeroth law, concept of temperature.

Work and Heat: Definition of work, units, work done at the moving boundary of system, work done in various non-flow processes, definition of heat, units, comparison of heat and work.

First Law of Thermodynamics for Non-Flow Systems: First law of thermodynamics for a closed system undergoing a cycle and for a change of state; energy - a property of system, internal energy and enthalpy. Specific heat at constant volume and constant pressure.

First Law of Thermodynamics for Flow Systems: Control mass, control volume, first law of thermodynamics for a control volume, steady flow energy equation and applications to engineering equipment and PMM-1.

Second Law of Thermodynamics: Thermal reservoirs, Kelvin-Plank and Clausius statements of second law of thermodynamics; Equivalence of Kelvin-Plank and Clausius statements, PMM-2; Carnot cycle, Carnot engine, corollary of Carnot theorem, absolute thermodynamic temperature scale.

Entropy: Definition of entropy, Clausius theorem, entropy change in reversible process temperature-entropy plot, inequality of Clausius, entropy change in an irreversible process, principle of increase of entropy, applications of entropy principle, entropy change of an ideal gas; availability and irreversibility.

Air standard cycles: Introduction to IC Engines, Performance analysis of Otto, Diesel, Dual and Brayton cycles.

Psychrometry: Properties of moist air, use of psychrometric chart ,Psychrometric processes.

Text Books:

1. Thermodynamics, an Engineering Approach - Yunus A. Cengel& Michael Boles, 6th Edition, Tata McGraw Hill, NewDelhi.
2. Engineering Thermodynamics - P. K. Nag, 5th Edition, Tata McGraw Hill, NewDelhi.

Reference Books:

1. Fundamentals of Thermodynamics - G. J. VanWyle
2. Engineering Thermodynamics - Cohen and Rogers, 5th Edition, Pearson Education India limited.
3. Heat and Thermodynamics - Zemansky, McGraw Hill, 5thEdition.

22PH2007 – MATERIALS TECHNOLOGY

L-T-P-S : 2-0-0-0
Credits : 2
Contact Hours : 2
Pre-requisite : NIL

Mapping of Course Outcomes with PO/PSO:

CO No	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand crystallography and various material testing methods	PO1,PO2	2
CO2	Understand and distinguish various types of materials based on their engineering applications	PO1,PO2	2
CO3	Apply the concepts of cooling curves and phase diagrams	PO1,PO2	3
CO4	Analyse various heat treatment processand their strengthening mechanisms.	PO1,PO2	3
CO5	Gain hands on experience to conduct various experiments of metallography and heat treatment process practically.	PO1,PO2	3

SYLLABUS:

Introduction-Testing

Introduction to Engineering materials, Properties: stress-strain diagrams for engineering materials; Crystallography, Crystal systems and Bravi's lattices, Crystal imperfections, Material testing Methods-Destructive and Non Destructive methods-Dye penetrate test, Magnetic flux test, Radiography and Ultrasonic test.

Materials

Ferrous and Non-Ferrous Materials, Ceramics, Composites and Nano-materials- Introduction, classification and applications

Smart Materials

Introduction, shape memory effect, classification of shape memory alloys, compositions, properties applications of shape memory alloys.

Alloys and Transformation

Constitution of alloys, Necessity of alloying, Solid solutions, Gibb's Phase rule, Cooling Curves, Phase diagrams-Introduction, classification based on components and transformations, construction, reactions involved in Fe-C, Cu-Ni and Al-Cu type.

Heat treatment

Strengthening mechanisms-Introduction, classification, Heat Treatment of steels-Introduction, stages, classification, Annealing, Normalising, Tempering, Hardening, Harden ability test by Jominy end quench apparatus, Isothermal transformation diagrams-TTT diagram &CCT diagram, special heat treatment techniques-Introduction, classification, surface hardening and case hardening methods such as carburising, nitriding, cyaniding and carbonitriding .

Text Books:

1. Material Science and Metallurgy - Dr.V.D.Kodgirie.
2.Material Science and Metallurgy – Daniel Yesudian, DG Harris Samuel.
3. Introduction to Physical Metallurgy – Sidney.H.Avener.

Reference Books:

1. Engineering Metallurgy by R.A.Higgins, Part I, App. Physical Met, ELBS.

2. Materials science and Engineering by V.Raghavan, PHI, Fifth Edition.
3. Physical Metallurgy by Lakhtin.

WEB REFERNCES/MOOCS:

1.https://nptel.ac.in/courses/113/104/113104014/
2.https://nptel.ac.in/courses/112/104/112104229/
3.https://freevideolectures.com/course/3104/principles-of-physical-metallurgy/23
4.https://nptel.ac.in/courses/112/108/112108150/

PROFESSIONAL CORE

22ME2106 - FLUID MECHANICS & HYDRAULIC MACHINES

L-T-P-S : 3-1-2-0
Credits : 5
Contact Hours : 6
Pre-requisite : Nil

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Apply the knowledge of fluid properties and the laws of fluid statics to estimate the total pressure, Centre of pressure and forces on submerged and floating bodies.	PO1-3	3
CO2	Apply continuity, Euler and Bernoulli equations and design different flow measuring devices	PO3-1	3
CO3	Apply momentum equation and boundary layer concepts to analyze the flow through pipes and impact of jets.	PO2-2	4
CO4	Analyze the performance of hydraulic turbines and pumps using velocity triangles and model similitude.	PO2-3	4
CO5	Conduct experiments to verify and apply various fluid flow principles and performance evaluation of various hydraulic machines like turbines and pumps	PO2-2	4

Syllabus:

Fluid Properties: Definition of fluid, properties of fluids - density, specific weight, specific gravity, viscosity, classification of fluids, surface tension, capillarity, vapor pressure.

Fluid Statics: Introduction, pressure, Pascal law, hydrostatic law, measurement of pressure, simple and differential manometers; total pressure and center of pressure on vertical, horizontal, inclined and curved surfaces.

Buoyancy: Buoyancy, forces on submerged bodies, stability of submerged and floating bodes.

Fluid kinematics: Introduction, types of fluid flow, discharge, continuity equation, potential function and stream function.

Fluid dynamics: Introduction, Euler‘s equation of motion, Bernoulli‘s equation and applications, venturi meter, orifice meter.

Flow through pipes: Introduction, major and minor energy losses, friction coefficient in laminar and turbulent flow, Hagen-Poiseuille law, Hydraulic gradient and total energy line, pipes in series and parallel, power transmission through pipes, Reynold‘s experiment and water hammer.

Boundary layer theory: Introduction, laminar and turbulent boundary layers, boundary layer thickness, displacement thickness, momentum thickness, energy thickness, boundary layer separation, methods of preventing separation.

Impact of Jets: Introduction to impulse-momentum equation and its applications, force exerted by jet on fixed target, moving target, and series of curved vanes.

Hydraulic Machines - Turbines: Introduction, types and classification Pelton wheel, Francis turbine,

Kaplan turbine-theory, work done and efficiency, design parameters using Dimensional analysis and model similitude**,** problems.

Hydraulic Machines - Centrifugal pumps: Definition of pump, classification, description and general principle of working; priming, work done and efficiency of a centrifugal pump, minimum starting speed, cavitation in centrifugal pumps, multi-stage pumps, problems on centrifugal pumps.

Text Books:

1. Fluid Mechanics by S. K. Som and G. Biswas, Tata McGraw Hill publications.
2. Fluid Mechanics by Yunus A. Cengel, McGraw Hill publications.
3. Fluid Mechanics and Hydraulic Machines, D. S. Kumar, Narosa Publishing House Private Limited.

Reference Books:

1. Fluid Mechanics by Frank M. White, Seventh Edition, McGraw Hill.
2. Fluid Mechanics & Hydraulics, K. R. Arora, Standard Book House, New Delhi.
3. Fluid Mechanics & Hydraulics, Modi & Seth, Standard Book House, New Delhi.

22ME2210 - ANALYSIS OF THERMAL SYSTEMS (with CFD & Linked to Project))

L-T-P-S : 3-1-0-4
Credits : 5
Contact Hours : 8
Pre-requisite : 22ME2105

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Apply the concept of pure substance to analyze the performance of vapor power cycles	PO2-3	4
CO2	Analyze the performance of IC engines by applying the concept of air standard cycles	PO2-3	4
CO3	Analyze the performance of gas turbine cycles and various jet propulsion systems	PO2-2	4
CO4	Analyze the performance of Bell Coleman and Vapour compression refrigeration systems	PO2-2	4
CO5	Analyze internal & external fluid flows through a commercial package Ansys - Fluent	PO5-2	4

Syllabus:

Vapour Power Cycles: Pure Substance definition, P-v-T surface; Use of steam tables; Saturation tables; Superheated tables; Identification of states & determination of properties, Mollier's chart.

Rankine cycle, Effect of pressure and temperature, Regenerative cycle, Binary vapour cycle.

IC Engines: Classification of I.C. Engines, working principles of S.I. and C.I. Engines (both 4 stroke and 2-stroke), combustion in S.I and CI engines. Parameters of performance - measurement of cylinder pressure, fuel consumption, air intake, exhaust gas composition, Brake power – Determination of frictional losses and Indicated power – Performance test – Heat balance sheet and chart.

Gas turbines: Overview of Gas turbines, Closed and open Brayton cycle gas turbines, Analysis of closed cycle gas turbine, turbine Efficiencies, Gas turbine cycle with intercooling, reheat and regeneration.

Jet propulsion: Turbo jet, Turbo prop, ram jet and Pulse jet engines, Rocket engines, principle of working, Thrust, work and propulsive efficiency

Introduction to Unconventional Energy Sources: Solar, Wind, Biomass, Geothermal, OTEC energy sources.

Refrigeration & Air conditioning: Methods of refrigeration, Refrigerator & heat pump, Reversed Carnot and Bell-Coleman cycles, Refrigerating effect, COP, Vapour compression and vapour absorption refrigeration systems.

Skilling

Analysis of Internal fluid flows, External fluid flows through Ansys - Fluent

Skilling Experiments list (using Ansys – Fluent)

1. Laminar fluid flow analysis through a pipe.

2. Turbulent fluid flow analysis through a pipe.
3. Laminar fluid flow analysis through a channel.
4. Turbulent fluid flow analysis through a channel.
5. Fluid flow analysis through a channel with corrugations.
6. Fluid flow analysis through a wavy channel.
7. Analysis of flow in between two rotating cylinders
8. Laminar fluid flow analysis over a flat plate.
9. Turbulent fluid flow analysis over a flat plate.
10. Analysis of flow in a lid driven cavity.
11. Laminar fluid flow analysis over a sphere.
12. Turbulent fluid flow analysis over a sphere.
13. Analysis of flow over a rotating cylinder
14. To Perform CFD analysis over Formula Racing Car.
15. To Perform CFD analysis over a bluff body.
16. To Perform CFD analysis over aerofoil.
17. Simulation and validation of broken dam problem
18. Analysis of R-T instability
19. Simulation of bubble rise in a quiescent liquid
20. Two phase flow through a channel with T- junction

Text Books:

1. Cengel & Boles “Engineering Thermodynamics”,Mc Graw Hill Publishers.
2. P.K.Nag “Basic and Applied Thermodynamics”,TMH, New Delhi.
3. V.Ganesan “I.C. Engines”,T.M.H.
4. ANSYS Fluent Tutorial Guide by ANSYS, Inc. Release 17.0 Southpoi.
5. “Computational fluid dynamics, the basics with applications” by john D Anderson.
6. S. V. Patankar, Numerical Heat Transfer and Fluid Flow, McGraw-Hill.
7. Mechanical Measurements by Thomas G. Beckwith, Addison-Wesley Publications

22ME3115-HEAT TRANSFER

L-T-P-S : 3-0-2-0
Credits : 4
Contact Hours : 5
Pre-requisite : Nil

Course Outcomes(Cos)-Program Outcomes (Pos)-Blooms Taxonomy Levels(BTL) Mapping table:

CO#	Course Outcome	PO/PSO	BTL
CO1	Apply Fourier law of conduction and combined conduction convection concepts to 1-D heat transfer problems.	PO1-3	3
CO2	Analyze heat transfer using extended surfaces, unsteady state heat transfer and 2-D conduction mode of heat transfer	PO2-3	4
CO3	Analyze the concepts of convection mode of heat transfer and heat transfer during phase change	PO2-2	4
CO4	Apply the principles of heat transfer to analyze and design different heat exchangers.	PO1-3, PO3-2	4
CO5	Experimental verification of various heat transfer parameters	PO1-3, PSO1-2	3

Course Objective:

To apply the knowledge of material and energy balances, mass *transfer* and chemical reaction engineering–I for solving problems involving heterogeneous reaction systems and to understand and apply the principles of non-ideal flow in the design of heat exchangers.

Syllabus:

Introduces fundamental processes of heat transfer.Fourier's law. Heat conduction processes including thermal resistance, lumped capacitance,fins

Elementary convection, including laminar and turbulent boundary layers, internal flow, and natural convection.

Heat transfer in boiling and condensation. Thermal radiation, including Stefan-Boltzmann law,

Small object in large enclosure, and parallel plates. Basic concepts of heat exchangers, shape factors

Text Books:

1. Heat Transfer – A practical approach, Yunus A. Cengel, Second Edition, Tata McGraw-Hill.
2. Introduction to Heat Transfer, Incropera. F. P. and Dewitt D. P., John Wiley and Sons.

Reference Books:

1. A Heat Transfer Text Book, Lienhard, J. H., Prentice Hall Inc.
2. Heat Transfer, Holman, J. P., McGraw-Hill Book Co., Inc., New York.
3. Heat Transfer – A Basic Approach, M. NecatiOzisik, McGraw-Hill Pub Co., New York.

22ME2101 – MECHANICS OF SOLIDS

L-T-P-S : 3-0-2-0
Credits : 4
Contact Hours : 5
Pre-requisite : 22PH1010

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Analyze stresses in members with axial loading or torsion	PO2	4
CO2	Analyze members with multi axial loading and lateral loading.	PO2	4
CO3	Analyze deflections and stresses in beams	PO2	4
CO4	Analyse columns and pressure vessels	PO2	4
CO5	Apply the theoretical concepts to conduct various experiments of strength of materials practically and analyze the data	PO5	3

Course Objective:

The objective of this course is to make the learner be able to identify stresses, strains and deflections in members that are loaded either axially or with torsion, or flexural loadings. Identify principal stresses, maximum shearing stress of two dimensional loaded structural members. Analyse beams with different Cross Sections and analyse columns and thin-walled pressure vessels

Syllabus:

Introduction: Types of Stress, Strains, Stress Strain Diagram, Hooke's Law.
Axially Loaded Members: Uniaxial Loading and Material Properties, Force-deformation Relationships and Static Indeterminacy; Compound Bars, Stress-strain-temperature Relationships. Trusses and their Deformations - Statically Determinate and Indeterminate Trusses.

Torsion: Introduction, Torsion of a Circular Bar, Non-Uniform Torsion, Transmission of Power by Circular Shafts, Strain Energy in Pure Shear and Torsion.

Multi axial stresses and strains: Multiaxial Stress and Strain- Relationships, Stress and Strain Transformations and Principal Stresses. Failure of Materials and Examples

Shearing Forces and Bending Moments: Shear Force and Bending Moment, Relationship Between Load, Shear Force and Bending Moment, Shear Force and Bending Moment Diagrams.
Beam Deflection, Symmetry, Superposition, and Statically Indeterminate Beams.

Stresses in Beams: Normal Stresses in Beams, Cross Section Shapes of Beams, Shear Stresses in Rectangular Beams, Shear Stresses in The Webs of Beams with Flanges.
Thin walled Pressure Vessels: Concepts of Hoop and Longitudinal Stresses, Simple Problems for Cylinders and Shells.
Columns: Buckling and Stability,

Text Books:

1. Gere & Goodno “Mechanics of Materials” Cengage Publishers
2. RC Hibbeler, “Mechanics of Materials” 10th edition, Pearson.

Reference Books:

1. Pytel A H and Singer F L, Harper Collins “Strength of Materials”, New Delhi.
2. Shames, I. H., Pitarresi, J. M “Introduction to Solid Mechanics”, Prentice-Hall, NJ.
3. E.P. Popov “Mechanics of Materials” Prentice Hall Publications
4. L S. Srinath “Strength of Materials”. Tata McGraw Hill
5. S.S. Rattan “Strength of Materials” Tata McGraw Hill

WEB REFERNCES/MOOCS:

1. https://ocw.mit.edu/courses/mechanical-engineering/2-001-mechanics-materials-i-fall-2006/syllabus/
2. https://nptel.ac.in/courses/112107146/

22ME2208 – MECHANICAL ENGINEERING DESIGN & INNOVATION (Analysis S/W)

L-T-P-S : 2-0-0-4
Credits : 3
Contact Hours : 6
Pre-requisite : 22ME2101

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Selection of appropriate materials in mechanical design	PO1, PSO2	3
CO2	Emphasize the fundamentals of mechanical behavior of materials	PO2, PSO2	3
CO3	Design of machine components for static strength	PO2	4
CO4	Design of machine components for fatigue strength	PO2	4
CO5	Analyse the effect of various loads on Mechanical components	PO2, PSO2	4
CO6	Design and execute a fully functional prototype	PO2, PSO2	6

Course Objective:

The objective of this course is to make the learner able to understand the fundamentals of mechanical behavior of materials, determine the mechanical properties of materials to design and solve the problems related to mechanical behavior of engineering materials.

Syllabus:

Need Identification and Problem Definition, Concept Generation and Evaluation, Embodiment Design, Selection of Materials and Shapes Mechanical behavior of engineering materials, Selection of Materials, Selection of Shapes.

Fundamentals of mechanical behavior of materials, as well as design with materials: elasticity, plasticity, fatigue, fracture, and creep

Design Philosophy, General considerations and procedure in machine design, preferred numbers, Codes & Standards, Reliability Design for Static Strength: Simple Stresses - Combined stresses - Torsional and Bending stresses - Factor of safety and theories of failure.

Design for Fatigue Strength: Stress concentration – Methods of reducing stress concentration factor, Design for fluctuating stresses- Endurance limit, Estimation of Endurance strength – Notch sensitivity– Goodman's line and Soderberg's line, Combined fluctuating stresses

Lab Syllabus:

Introduction to Finite Element Method.

Dynamic Analysis: Modal Analysis, Harmonic Analysis, Fatigue analysis, Random Analysis.
Analysis of metals and composites: Linear and non-linear, Static structural and dynamic analysis of:

- Pressure Vessels (Thick and Thin),

- Torsion of Shafts,
- Plates (Finite Width and Infinite Width)
- Stress concentration Factors for geometrical imperfections.
- Shafts subjected to combined loading.
- Analysis of metals and composites: Linear and non-linear, Static structural and dynamic analysis
- Effect of chamfers and fillets.
- Pretension of bolts,
- Fatigue (Low cycle and high cycle),
- Generation of S-N curve from Low cycle fatigue.
- Analysis of fracture modes.

Skilling Syllabus:

- To identify a problem
- To develop a concept to solve the problem going through various phases of conceptualization / Design thinking.
- To prepare model from concept and analyse further to improve the design.
- Incorporate reliability, risk, and safety in design iterations
- Develop a functional prototype.

Text Books:

1. Engineering Design by George E. Dieter, 4th Edition, McGraw-Hill International Editions.
2. Product Design and Development, 6th ed., by K.T. Ulrich and S.D. Eppinger, 2015

Reference Books:

1. Gere & Goodno “Mechanics of Materials” Cenage Learning India Pvt Ltd
2. Engineering Design Process by Haik & Shahin, Cengage learning.
3. The Mechanical Design Process, 5th ed., by D. Ullman, 2015
4. Machine Design, 5th ed., by R.L. Norton, 2013.
5. Finite Element method by R.Chandrapatla.

22ME2211-KINEMATICS OF MACHINES (With Adams s/w)

L-T-P-S : 2-0-2-0
Credits : 4
Contact Hours : 4
Pre-requisite : Nil

Mapping of Course Outcomes with PO/PSO:

CO No	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Analyze kinematically suitable mechanisms for required motion of machinery	PO4	4
CO2	Analyze velocity and acceleration diagrams and interpret the data	PO4	4
CO3	Construct cam profiles and Analyze gears and gear trains kinematically	PO4	4
CO4	Analyze gears and gear trains kinematically Analyze mechanisms dynamically	PO2	4
CO5	Apply the theoretical concepts to analyse different mechanisms by using the simulation software for data analysis.	PO4	4

SYLLABUS:

Mechanisms and Machines: Introduction to Plane and Space Mechanisms, Kinematic Pairs, Kinematic Chains and their Inversions, Mobility and range of movement - Kutzbach and Grubler‘s criterion, Grashof‘s criterion.
Velocity analysis: Velocity analysis using IC and relative velocity method. Acceleration analysis. Synthesis of four bar mechanism.
Cams: cam profiles of knife edge, roller and offset followers of reciprocating motion.
Gears and Gear trains: Gears – terminology, fundamental law of gearing, involute profile. Interference and undercutting. Gear Trains – simple, compound and epicyclic gear trains.

Text Books:

1. David H. Myszka ―Machines and Mechanisms-Applied Kinematic Analysis‖, 4thEdition, Prentice Hall
2. Robert Norton ―Kinematics and Dynamics of Machinery‖ 1st Edition, Tata McGraw - Hill Education, (2009)
1. Shigley J.E., and Uicker J.J ―Theory of Machines and Mechanisms‖, McGraw Hill, (1995).
2. S.S.Ratan, Theory of machines 3rd edition, McGraw Hill,

Reference Books:

1. Thomas Bevan ―Theory of Machine‖ CBS Publications.
2. Rao, J. S ―The Theory of Machines through Solved Problems‖, New Age International.
3. A.Ghosh and A.K.Mallik ―Mechanisms and Machine Theory‖, 3rdedition, EWP Pvt.Ltd.

22ME3118-DYNAMICS OF MACHINES

L-T-P-S : 2-0-0-0
Credits : 2
Contact Hours : 2
Pre-requisite : Nil

Mapping of Course Outcomes with PO/PSO:

CO No	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Apply analytical / graphical methods for balancing of rotary and reciprocating masses	PO1	3
CO2	Analyze the forces in linkages and the effect of the Gyroscopic couple in vehicles	PO2	4
CO3	Analyze the free vibration response of single DOF systems	PO2	4
CO4	Analyze the forced vibration response of single DOF systems	PO2	4

Syllabus

CO-1

Balancing: Introduction, Static balancing, dynamic balancing, Balancing of Several Masses in Different planes, Balancing of Reciprocating Mass, Secondary Balancing

CO-2

Dynamic force analysis: Dynamic analysis of linkages; Transferring of a Force from one plane to another, Force analysis of Slider crank mechanism.

Gyroscopes: Gyroscopic Effect on Naval Ships, Stability of an Automobile, Stability of a Two-Wheel vehicle, Four-Wheeler

CO-3

Free-undamped and damped vibrations of single DOF systems

CO-4

Forced vibration of single degree of freedom systems, effect of damping; vibration isolation; resonance; critical speeds of shafts.

TEXT BOOKS:

1. Robert Norton ―Kinematics and Dynamics of Machinery‖ 1st Edition, Tata McGraw - Hill Education, (2009)
2. A.Ghosh and A.K.Mallik ―Mechanisms and Machine Theory‖, 3rdedition, EWP Pvt.Ltd
3. Mechanical Vibrations,S.S.Rao,Pearson Education Inc. (4th Ed.), 2007
4. Mechanical Vibrations by R.V.Chalam

REFERENCE BOOKS:

1. Shigley J.E., and Uicker J.J ―Theory of Machines and Mechanisms‖, McGraw Hill, (1995).
2. S.S.Ratan, Theory of machines 3rd edition, McGraw Hill,
3. Mechanical Vibrations,S.Tamadonni& Graham S.Kelly, Schaum‘sOut line Series, Mc-Graw Hill Inc, 1998
4. Mechanical Vibrations by G. K. Groover. Nem Chand & Bros.

22ME3113 – MACHINE DESIGN(Linked to project)

L-T-P-S : 3-1-0-4
Credits : 5c
Contact Hours : 8
Pre-requisite : 22ME2208

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Design of shafts and couplings	PO2, PSO1	4
CO2	Design of fasteners	PO4, PSO1	4
CO3	Selection of appropriate bearings and drives	PO2, PSO1	5
CO4	Design of gears	PO2, PSO1	4
CO5	Design various mechanical systems	PO4, PSO2	5

Course Objectives:

- To Design different types of mechanical drives like flat and V-belt drives, chain drives, Design of brakes and clutches, Select of journal bearings and anti-friction bearings, Design of spur, helical, bevel and worm gears.
- This course prepares for the capstone design course by providing understanding of all necessary steps and project management communication, documentation necessary to successfully execute the capstone design project.

Syllabus:
Shafts: Design of solid and hollow shafts for strength and rigidity, Design of shaft for variable load, Design of shafts for gear and belt drives.
Couplings: Design of Rigid and Flexible Couplings
Design of Helical springs, Torsion springs, Spiral springs, Leaf springs.
Design of Fasteners:
Welded joints: Design of Welded joints, Strength of welded joints, Circular fillet welds-bending and torsion, Welded joint with eccentric loading,
Bolted joints: Design of bolts with pre-stresses - Design for leak Proof Joints – Design of joints under eccentric loading - Bolt of uniform strength.
Power Screws: Types - Mechanics of power screws, Efficiency of Square and Self-locking screw
Belt Drives: Selection of flat and V-belts from manufacturer's catalogue, Belt tensioning methods, Construction and applications of timing belts.
Chain Drives: Polygonal effect, Power rating of roller chains, Construction of sprocket wheels.
Bearings: modes of Lubrication, Sliding contact bearing design, bearing materials, selection of lubricant. Rolling contact bearings- selection of ball, roller bearings- under static load, dynamic load.
Brakes: Analysis and Design of Block brakes, internal shoe Brakes, End shoe Brakes, Pivoted shoe Brakes, Band Brakes, Temperature raise, Friction materials.
Spur Gears: Force analysis, Beam strength (Lewis) equation, Estimation of module based on beam and wear strength.

Helical Gears: Transverse and normal module, Estimation of dynamic load by velocity factor and Buckingham's equation, Design of helical gears.
Bevel Gears: Design criteria of bevel gears, Beam and wear strengths, Dynamic tooth load by velocity factor and Buckingham's equation, Effective load, Design of straight tooth bevel gears,
Worm Gears: Design and analysis of worm gear drive

Skilling Syllabus:

As a part of skilling in this course, each student group shall take up three design projects and one seminar.

1. Design Projects (3 design projects)

Project 1 shall be based on any one of the following topics.

i. Cotter joint/knuckle joint/turn buckle for a specified application.
ii. Transmission Shaft/Machine tool spindle/coupling for specified application.
iii. Hand or foot operated levers/lever for safety valve.

Project 2 shall be based on any one of the following topics.

i. Bench vice / Machine vice for specified applications.
ii. Bottle type / toggle jack for vehicles.
iii. Lead screw for machine tool / other applications.

Project 3 shall be based on any one of the following topics.

i. design project based on Two Stage Gear Box (the two stages having different types of gear pairs)
ii. design project based single stage worm gear box.

Each design project shall consist of two full imperial (A1) size sheets involving assembly drawing with a part list and overall dimensions and drawings of individual components. Manufacturing tolerances, surface finish symbols and geometric tolerances should be specified for important surfaces. A design report giving all necessary calculations of the design of components and assembly should be submitted in a separate file. Design data book shall be used wherever necessary to achieve selection of standard components.

Note:

1. Design project should be assigned to group of 4 to 5 students.
2. Assembly drawing of project should be drawn using any CAD software.
3. Detailed parts of project should be drawn manually.
4. Design projects should be practical oriented, below is the list of practical applications:
    i. Design of gearbox for windmill application
    ii. Design of gearbox for sluice gate application.
    iii. Design of gearbox for machine tool applications like Lathe, Drilling, Milling machines etc.
    iv. Design of in-line gearbox for Automobile application.
    v. Design of gearbox for building Elevator
    vi. Design of gearbox for Hoist.
    vii. Design of gearbox for 2-wheeler.
    viii. Design of gearbox for Tumbling barrel (Mixer).

ix. Design of gearbox for Cannon adjustment mechanism (Military application).
x. Design of gearbox for Worm gear box for Sugar Industry.

5. Each component design should include.
    1. Design considerations
    2. Material selection using weighted point method and obtaining material properties.
    3.Selection of Factor of safety and calculation of allowable stresses
    4. Force or torque analysis
    5.Stress analysis.
    6.application of theories of failure
    7.determining the shape and size.
    8.Selection of standard sizes.
    9.Analysis
    10. optimization

2. Presentation by a project batch (PPT/slides) (on any one topic):

i. Application of belt drive and its selection method for Industrial application. (By using Manufacturer's Catalogue).
ii. Application of chain drive and its selection method for Automobile application. (By using Manufacturer's Catalogue).
iii. Mounting of machine elements on transmission shaft (like Bearings, gears, Pulley, Sprocket, etc).
iv. Selection of Bearing from Manufacturer's Catalogue.
v. Design for aesthetic and ergonomic considerations
vi. design for manufacturing
vii. Design for assembly
viii. Design for ISO14000
ix. Design for societal aspects.
x. optimum design.
xi. design based on reliability.

Text Books:

1. V.Bhandari "Design of machine elements", Tata McGraw Hill book Co
2. M.F.Spotts Design of Machine Elements " Pearson Education
3. The Mechanical Design Process, 5th ed., by D. Ullman, 2015
4. Product Design and Development, 6th ed., by K.T. Ulrich and S.D. Eppinger, 2015
5. Machine Design, 5th ed., by R.L. Norton, 2013.

Reference Books:

1. Shigley J.E, "Mechanical Engineering Design", McGraw-Hill, 1996
2. Black P.H. and O. Eugene Adams, "Machine Design", McGraw Hill Book Co. Ltd
3. R.C.Bahl and V K Goel "Mechanical Machine Design" Standard Publishers
4. Machine Design by Dr.N.C.Pandya&Dr.C.S.Shah, Charotar Publishing House
5. Finite Element method by R.Chandrapatla.

22ME2107 – MANUFACTURING PROCESSES

L-T-P-S : 3-0-2-0
Credits : 4
Contact Hours : 5
Pre-requisite : Nil

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand and apply the casting processes	PO1, PSO2	2
CO2	Apply the welding processes and identify the faults in welding processes	PO3, PSO1	2
CO3	Apply principles of cold/hot forming processes	PO3, PSO2	4
CO4	Apply sheet metal processes and design sheet metal dies.	PO3, PSO1	3
CO5	Fabricate the parts using manufacturing processses	PO2, PSO2	3

Course Objective:

The objective of this course is to make the learner able to identify manufacturing processes in mechanical industries to prepare the physical product and apply manufacturing processes to produce a product used in industries, houses, automobiles, and agriculture purposes.

Syllabus:

Casting - Patterns and Pattern making, Allowances, Moulding methods and processes, Design considerations in casting, Riser and gating design, Different castings - Sand castings, pressure die casting, permanent mould casting, centrifugal casting, precision investment casting, shell Moulding, continuous casting-squeeze casting, electro slag casting, casting defects and Inspection of castings.

Joining Processes - Types of welding - Arc welding, Shielded metal arc welding, GTAW, GMAW, SAW, Resistance welding, Thermit welding, Gas welding, Soldering, brazing, Electron beam and Laser welding, weld stress-calculations, design of weld size, estimation of weld dilution, heat input, effect of welding parameters, Inspection of welds, Defects in welding, causes and remedies.

Metal Forming - Hot/Cold forming processes, Metallurgical aspects of metal forming, Forging and rolling processes: Forging principle, parameters and calculation of forces and power requirements during forging, Rolling processes, calculation of forces and geometrical relationship in rolling, analysis of rolling load, torque and power. Rolling and forging defects, causes and remedies. Types of Extrusion processes and drawing processes, Problems on extrusion and drawing.

Sheet metal forming processes - Sheet metal / Press working operations, Types of presses and selection of presses, HERF processes - Electro hydraulic forming, Magnetic pulse forming.

Text books:

1. Lindberg,"Processes and Materials of Manufacture", Prentice hall India (p) Ltd.
2. SeropeKalpakjian, Steven R. Schmid "Manufacturing Engineering and Technology" (4th Edition) Prentice Hall 2000-06-15 ISBN: 0201361310
3. P.N.Rao "Manufacturing Technology", TMH Ltd 1998(Revised edition)

4. Dieter “Mechanical Metallurgy”, Revised edition 1992, McGrawhill
5. AmitabhaGhosh and Asok Kumar Mallik “ Manufacturing science TMH publisher

22ME2212-MANUFACTURING TECHNOLOGY (Linked to Project)

L-T-P-S : 3-0-2-0
Credits : 4
Contact Hours : 5
Pre-requisite : Nil

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand and analyze metal cutting processes	PO2, PSO1	3
CO2	Understand working machine tools and related operations	PO1, PSO2	2
CO3	Understand Non-traditional machining processes and automation of production lines	PO1, PSO2	2
CO4	Implement CIM concepts and measuring and inspecting of components	PO4, PSO1	3
CO5	Implement modern manufacturing techniques	PO5, PSO2	3

Syllabus:

Metal cutting - Single and multi-point cutting tools, Orthogonal / Oblique cutting, various force components- merchant's force circle diagram and problems, Chip formation, Tool wear and tool life, Cuttingtool materials, Cutting fluids.

Machine Tools - Lathe, milling, drilling, boring, shaper, slotter, planer – mechanics and operations, principles of work holding, jigs and fixtures.

Non-traditional machining processes - Abrasive Jet Machining, Water Jet Machining, Ultrasonic Machining, Electrical Discharge Machining and Electro chemical machining - principle and process parameters, MRR.

Automation and CNC: Reasons and strategies of Automation, NC, CNC, DNC – Basic Components, economics and comparison, Absolute and Incremental Positioning, CNC Programming – Turning, Milling and Drilling.

Computer Integrated Manufacturing: Basic concepts of CAD/CAM and their integration tools; additive manufacturing.

Metrology and Inspection: Limits, fits and tolerances; linear and angular measurements; comparators; interferometry; form and finish measurement; alignment and testing methods; tolerance analysis in manufacturing and assembly; concepts of coordinate-measuring machine(CMM).

Text Books:

1. Lindberg,"Processes and Materials of Manufacture", Prentice hall India (p) Ltd.
2. Serope Kalpakjian, Steven R. Schmid "Manufacturing Engineering and Technology" (4th Edition) Prentice Hall 2000-06-15 ISBN: 0201361310

Reference Books:

1. P.N.Rao "Manufacturing Technology", TMH Ltd 1998(Revised edition)
2. Dieter "Mechanical Metallurgy", Revised edition 1992, Mcgraw
3. CAD/CAM by Gimmers and Groovers

22ME3116-OPTIMIZATION TECHNIQUES

L-T-P-S : 2-0-0-0
Credits : 2
Contact Hours : 2
Pre-requisite : Nil

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Identify Optimum solutions for various single objective problems using Linear Programming models	PO1.PO5	2
CO2	Identify Optimum Solutions through Transportation and Assignment models	PO3	2
CO3	Identify Optimum Solutions through Game theory, DPP, Queuing theory & Simulation models	PO3,PSO2	2
CO4	Solve project management problems using CPM, PERT and inventory	PO3,PSO2	2

Syllabus:

Linear Programming Problem: Introduction to Operations Research, Models, Scope, limitations, applications of OR. Introduction, Graphical method, Simplex method, Big M method, Two phase method, multiple solutions, infeasible solutions, unbounded solution, degeneracy, Dual Simplex method.

Transportation: Introduction, methods of feasible solution, optimality test, Degeneracy in transportation problem, unbalanced transportation problem. Assignment Problem**:** Introduction, Hungarian method, travelling salesman problem.

Queueing Theory: Introduction, single channel, Poisson arrival, exponential service time with finite population and infinite population. Dynamic Programming – Introduction, Bellman's principle of optimality, application to shortest route problem.

Project Management by CPM/PERT: Introduction, simple network techniques, construction rules of drawing, Fulkerson's rule, Critical path method (CPM) – floats, critical path, project duration.

PERT – Introduction, different time estimates, expected time, variance, expected project duration and probability of completion.

Text Books:

1. F.S.Hiller, G.J.Liberman, Introduction to Operations Research, 2005, Tata Mc-Graw Hill.
2. H.A.Taha, Operations Research, 2008, Pearson Education.

Reference Books:

1. S.D. Sharma, Operations Research, 11th Edition, 2002, KedarNath Ram Nath& Co.
2. R.Paneerselvam, Operations Research, 2nd Edition, 2006, PHI

22ME4120-INSTRUMENTATION & CONTROL

L-T-P-S :2-0-2-0
Credits :3
ContactHours : 4
Pre-requisite :NIL

CO#	Course Outcome	PO/PSO	BTL
CO1	To identify various measurement systems and their purpose in typical instruments	PO1, PSO1	2
CO2	Analyze temperatures, flow and different level indicator measurement systems	PO2, PSO1	3
CO3	Analyze various instruments to measure stress-strain and Humidity parameters	PO2, PSO1	3
CO4	Understand different elements of control systems	PO1, PSO1	2
CO5	Study and analyse the different measurement systems	PO1, PO2, PSO1	3

Syllabus

Definition – Basic principles of measurement – Measurement systems, Measurement of Displacement: Theory and construction of various transducers to measure displacement – Using Piezo electric, Inductive, capacitance, resistance, Measurement of Speed: Mechanical Tachometers, Electrical tachometers, Non- contact type Stroboscope;

Measurement of Temperature: Various Principles of measurement-Classification: Expansion Type: Bimetallic Strip- Liquid in glass Thermometer; Electrical Resistance Type: Thermistor, Thermocouple, RTD; Radiation Pyrometry: Optical Pyrometer; Measurement of Level: Direct methods – Indirect methods – Capacitive, Radioactive, Ultrasonic, Magnetic, Cryogenic Fuel level indicators –Bubbler level indicators.Flow measurement: Rotameter, magnetic, Ultrasonic, Turbine flowmeter, Hot – wire anemometer, Laser Doppler Anemometer (LDA).

Stress-Strain measurements: Various types of stress and strain measurements –Selection and installation of metallic strain gauges; electrical strain gauge – gauge factor – method of usage of resistance strain gauge for bending, compressive and tensile strains Measurement of Humidity: Moisture content of gases, Sling Psychrometer, Absorption Psychrometer, Dew point meter. Measurement of Force, Torque and Power- Elastic force meters, load cells, Torsion meters, Dynamometers.

Elements of Control Systems: Introduction, Importance – Classification – Open and closed systems- Servomechanisms – Examples with block diagrams – Temperature, speed and position control systems- Transfer functions- First and Second order mechanical systems

TEXT BOOKS:

1. Principles of Industrial Instrumentation & Control Systems, - Alavala, - Cengage Learning
2. Basic Principles – Measurements (Instrumentation) & Control Systems – S. Bhaskar – Anuradha Publications.

REFERENCE BOOKS:

1. Measurement Systems: Applications & design, E. O. Doebelin, TMH
2. Instrumentation, Measurement & Analysis, B.C. Nakra& K.K. Choudhary, TMH
3. Experimental Methods for Engineers / Holman
4. Mechanical and Industrial Measurements / R. K. Jain/ Khanna Publishers.
5. Mechanical Measurements / Sirohi and Radhakrishna / New Age International.

List of Experiments:

1. Temperature measurement using Arduino
2. Study and calibration of a Rotameter for flow measurement.
3. Study and calibration of LVDT transducer for displacement measurement.
4. Flow measurement using Arduino.
5. Humidity measurement using Arduino
6. Strain measurement using Arduino
7. Vibration measurement using Arduino
8. Thickness measurement using Arduino.
9. Level measurement using Arduino
10. Position control using Arduino using Servo motor
11. Speed control of DC motor using Arduino
12. Calibration of Resistance Temperature Detector (RTD) for temperature measurement

22ME3119-ROBOTICS

L-T-P-S : 2-0-0-0
Credits : 2
Contact Hours : 2
Pre-requisite : NIL

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand the functions of the basic components of a Robot.	PSO1	2
CO2	Applications of drive systems and end effectors	PO1, PSO1	3
CO3	Understand the image processing techniques in Robot vision	PSO1	2
CO4	Understand the various Robot Languages	PSO1	2

Syllabus:

FUNDAMENTALS OF ROBOT
Robot - Definition - Robot Anatomy - Co ordinate Systems, Work Envelope Types and Classification-Specifications-Pitch, Yaw, Roll, Joint Notations, Speed of Motion, Pay Load- Robot Parts and their Functions-Need for Robots-Different Applications.

ROBOT DRIVE SYSTEMS AND END EFFECTORS
Pneumatic Drives-Hydraulic Drives-Mechanical Drives-Electrical Drives-D.C. Servo Motors, Stepper Motors, A.C. Servo Motors-Salient Features, End Effectors-Grippers-Mechanical Grippers, Pneumatic and Hydraulic- Grippers, Magnetic Grippers, Vacuum Grippers; Two Fingered and Three Fingered Grippers; Internal Grippers and External Grippers; Selection and Design Considerations.

SENSORS AND MACHINE VISION

Requirements of a sensor, Principles and Applications of the various types of sensors- Position sensors - Piezo Electric Sensor, LVDT, Resolvers, Optical Encoders, pneumatic Position Sensors, Range Sensors. Image Processing and Analysis-Data Reduction, Segmentation, Feature Extraction, Object Recognition, Other Algorithms, Applications- Inspection, Identification, Visual Serving and Navigation.

ROBOT PROGRAMMING
Lead through Programming, Robot programming Languages-VAL, AML, RAIL Programming-Motion Commands, Sensor Commands, End Effector commands and simple Programs.

TEXT BOOKS:

1. Klafter R.D., Chmielewski T.A and Negin M., “Robotic Engineering - An Integrated Approach”, Prentice Hall, 2003.
2. Groover M.P., “Industrial Robotics -Technology Programming and Applications”, McGraw Hill, 2001.

3. **Mittal & Nagrath., "Robotics & Control", Mc Graw Hill Education.**

REFERENCES:

1. Craig J.J., "Introduction to Robotics Mechanics and Control", Pearson Education, 2008.
2. Deb S.R., "Robotics Technology and Flexible Automation" Tata McGraw Hill Book Co., 1994.
3. Koren Y., "Robotics for Engineers", Mc Graw Hill Book Co., 1992.
4. Fu.K.S.,Gonzalz R.C. and Lee C.S.G., "Robotics Control, Sensing, Vision and Intelligence", McGraw Hill Book Co., 1987.
5. Janakiraman P.A., "Robotics and Image Processing", Tata McGraw Hill, 1995.
6. Surender Kumar, "Industrial Robots and Computer Integrated Manufacturing", Oxford and IBH Publishing Co. Pvt. Ltd., 1991.

22ME3114-INDUSTRY 4.0 & DESIGN OF CYBER PHYSICAL SYSTEMS

L-T-P-S : 3-0-0-4
Credits : 4
Contact Hours : 7
Pre-requisite : NIL

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Apply basic principles of Industry 4.0: Cyber Physical Systems in solutions that require problem solving	PO1-1, PSO1-1	2
CO2	Implement the concepts of Cybersecurity in Industry 4.0 and develop applications	PO3-2, PSO1-2	3
CO3	Implement the concepts of IoT and develop applications	PO3-2, PSO1-2	3
CO4	Implement the concepts of IIoT and develop applications	PO3-2, PSO1-2	3
CO5	Apply the concepts of Cyber security and Control Systems to develop real time applications	PO3-3, PSO2-3	4

Syllabus:

Introduction: Sensing & actuation

Communication-Part I, Part II, Networking-Part I, Part II, Industry 4.0: Globalization, The Fourth Revolution, LEAN Production Systems, Industry 4.0: Cyber Physical Systems and Next Generation Sensors, Collaborative Platform and Product Lifecycle Management

Cybersecurity in Industry 4.0

Basics of Industrial IoT: Industrial Processes-Part I, Part II, Industrial Sensing & Actuation, IIoT-Introduction, Industrial IoT: Business Model and Reference Architecture: IIoT-Business Models-Part I, Part II, IIoT Reference Architecture-Part I, Part II. Industrial IoT- Layers: IIoT Sensing-Part I, Part II, IIoT Processing-Part I, Part II, IIoT Communication-Part I.

Industrial IoT- Layers

IIoT Communication, IIoT Networking-Part I, Part II, Part III. Industrial IoT: Big Data Analytics and Software Defined Networks: IIoT Analytics - Introduction, Machine Learning and Data Science Part I, Part Il, Industrial IoT: Big Data Analytics and Software Defined Networks: SDN in IIoT-Part I, Part II, Data Center Networks, Industrial IoT

Industrial IoT: Security and Fog Computing

Fog Computing in IIoT, Security in IIoT-Part I, Part II, Industrial IoT- Application Domains, Industrial IoT- Application Domains: Healthcare, Power Plants, Inventory Management & Quality Control, Plant Safety and Security (Including AR and VR safety applications), Facility Management. Industrial IoT-Application Domains: Oil, chemical and pharmaceutical industry, Applications of UAVs in Industries, Real case studies

Text books:

1. Artificial Intelligence a Modern Approach by Peter Norvig, Rusell
2. Introduction to Industrial Internet of Things and Industry 4.0 by Anandarup Mukherjee, Chandana Roy and Sudip Misra.
3. Industry 4.0 The Industrial Internet of Things by Alasdair Gilchrist.

Reference Books:

1. Internet of Things – A hands-on approach, Arshdeep Bahga and Vijay Madisetti
2. Architecting for the Cloud-AWS Best Practices.

Web References / MOOCs:

1. Introduction to Industry 4.0 and Industrial Internet of Things by Prof. Sudip Misra IIT Kharagpur. https://nptel.ac.in/courses/106105195

List of Experiments:

1) Write a python program to solve Water Jug Problem in Artificial Intelligence?
2) Write a python program to implement a simple Chatbot?
3) Introduction to Arduino IDE and Installation of Arduino IDE
4) Connecting and making LED to blink
5) Connecting and making LED on using pushbutton
6) Controlling LED by using LDR sensor
7) NodeMCU V3 For Fast IoT Application Development
8) Connecting and controlling Servo motor using Arduino Micro controller.
9) Connecting and controlling DC motor using Arduino Micro controller.
10) Interface Smoke Sensor to activate with a warning RED
11) Connecting and controlling LED using Infrared sensor and Arduino Micro controller

Certifications Required:

It is mandatory for every student to get certification on “Robotic Process Automation”. Based on the grade obtained in this certification will be considered for In-Semester Summative Evaluation. It is essential for the student to complete “Introduction to Industry 4.0 and Industrial Internet of Things” from NPTEL platform by the end of the semester and get certification. A separate examination will be conducted within the university for those who are not able to complete the NPTEL certification.

PROFESSIONAL ELECTIVES

21ME4051 - THEORY OF ELASTICITY AND PLASTICITY

L-T-P-S : 3-0-0-0
Credits : 3
Contact Hours : 3
Pre-requisites : 22ME2208

Mapping of Course Outcomes with PO/PSO:

CO#	Course outcome	PO/PSO	BTL
CO1	Analyze stresses and strains in planes in elastic or plastic region	PO1, PO2	4
CO2	Solve 2-D problems in rectangular Components	PO1, PO2	4
CO3	Analyze stresses and strains in 3-D problems	PO1, PO2	4
CO4	Analyze Beams and frames in plasticity applications	PO1, PO2	4

Syllabus:

Introduction:

Elasticity: Components of stress and strain: plane stress and plane strain;

Plasticity: Foundations of plasticity, the criterions of yielding, stress-strain relationship, stress resolving postulates, rule of plastic flow.

2-D Problems in rectangular co-ordinates: solution by polynomials; St.Venants principle; determination of displacements; Bending of a cantilever loaded at the end; Bending of a beam under uniform load.

Stress and strain analysis in 3-D problems: Principle stresses and their determination; Stress invariants; strains at a point. Principal axis of strain; Elementary problems.

Plastic analysis of beams and frames: Limit analysis of beams and frames; Minimum weight design, influence of axial force.

Text Books:

1. Theory of Elasticity by Timeshanko, McGrawhill Publications.
2. Theory of Plasticity by J.Chakarbarthy, McGrawhill Publications.

Reference Books:

1. Theory of Elasticity by Y.C.Fung.
2. Engineering Plasticity; Slater R.A.C: John Wiley and Son: NY 1977

21ME4052 – FINITE ELEMENT METHOD

L-T-P-S : 2-0-2-0
Credits : 3
Contact Hours : 3
Pre-requisite : 22PH1010

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Analyze one DOF free and forced undamped vibration systems	PO1, PSO1	3
CO2	Analyze and control of one DOF forced damped vibration systems	PO2, PSO1	4
CO3	Analyze and control of Two and Multi DOF vibration systems	PO2, PSO1	4
CO4	Analyze continuous systems and vibration measurement.	PO2, PSO1	3

Syllabus:

FUNDAMENTALS OF VIBRATION: Introduction -Sources of Vibration-Mathematical Models-Displacement, velocity and Acceleration.
Single Degree Freedom Systems: Free and Forced vibration of undamped systems.
Forced Vibration of Damped with Harmonic Excitation System, Vibration isolation - Vibrometers and accelerometers - Response to Arbitrary and non - harmonic Excitations – Transient Vibration –Impulse loads-Critical Speed Of Shaft-Rotor systems. Vibration Isolation methods - Dynamic Vibration Absorber, Torsional and Pendulum Type Absorber - Damped Vibration absorbers. Specification of vibration limits –Vibration severity standards - Vibration as condition monitoring tool.
TWO DEGREE FREEDOM SYSTEM: Introduction- –Coordinate Couplings and Principal Coordinates
MULTI-DEGREE FREEDOM SYSTEM AND CONTINUOUS SYSTEM: Multi Degree Freedom System –Influence Coefficients and stiffness coefficients-Flexibility Matrix and Stiffness Matrix – Eigen Values and Eigen Vectors-Matrix-Iteration Method –Approximate Methods: Dunkerley, Rayleigh's, and Holzer Method.
Eigen Values & Eigen vectors for large system of equations using sub space, Lanczos method.
Continuous System: Vibration of String, Shafts and Beams. Introduction to Active and Semi-active Vibration Control.
Vibration Measurement: Basics, data acquisition, FFT analysis and filters

Text Books:

1. Mechanical Vibrations, S.S. Rao, Pearson Education Inc. (4th Ed.), 2007.
2. Mechanical Vibrations by G. K. Groover. Nem Chand & Bros.
3. Vibration and Control, D. J. Inman, John Willey & Sons Inc, 2002
4. Mechanical Vibrations, S. Tamadonni & Graham S. Kelly, Schaum's Outline Series, Mc-Graw Hill Inc, 1998.

21ME4053 – MODELING, ANALYSIS & DESIGN OF ROBOTIC SYSTEMS

L-T-P-S : 2-0-2-0
Credits : 3
Contact Hours : 4
Pre-requisites : Nil

Mapping of Course Outcomes with PO/PSO:

CO#	Course outcome	PO/PSO	BTL
CO1	Apply the forward and inverse dynamics for robots	PO1, PO2	3
CO2	Model and simulate of motion of robots and manipulators	PO1, PO2	3
CO3	Kinematic modeling and analysis of mechanical and robotic systems	PO1, PO2	4
CO4	Implementation of the control on mechanical / robotic systems	PO1, PO2	3

Syllabus:

Introduction to Robot Dynamics and Kinematics: Forward Dynamics and Inverse Dynamics – Importance – Spatial description and transformations – Different types of dynamic formulation schemes – Lagrangian formulation for equation of motion for robots and manipulators.
Dynamic Modeling and Simulation: Modeling of motion of robots and manipulators using Newton – Euler equations – State space representation of equation of motion and system properties – Importance of Simulation and its types – Numeric Integration solvers and their role in numeric simulation - Numeric simulation of robots and manipulators using MATLAB / Simulink module.
Introduction to Robot Control: Introduction – Need and types of control schemes for robots – joint space control schemes with an example – task space control schemes with an example.
Kinematics and Dynamics Modeling: Kinematic modeling and analysis of mechanical and robotic systems – Forward kinematics and inverse kinematics – Jacobian and velocity analysis – Dynamic/ Kinetic modeling and analysis of mechanical and robotic systems – Forward dynamics, statics and performance analysis.
Kinematics and Dynamics Controlling: System control of mechanical / robotic systems using Adams – Inverse dynamics, regulatory control and tracking control.

Text books:

1. Kelly R, Santibanez V and Loria A, ―Conrol of Robot Manipulators in Joint Space‖, Springer, 2005.
2. Devendra K Chaturvedi, ―Modeling and Simulation of Systems using MATLAB and Simulink, CRC press, 2010.

21ME4054 – CREEP, FATIQUE AND FRACTURE MECHANICS

L-T-P-S : 3-0-0-0
Credits : 3
Contact Hours : 4
Pre-requisites : 22ME2208

Mapping of Course Outcomes with PO/PSO:

CO#	Course outcome	PO/PSO	BTL
1	Assess the failure of unflawed structural components	PO2, PO4	4
2	Assess the fatigue life of structural components under the specified load spectrum	PO2, PO4	4
3	Evaluate the fracture toughness and assess the life of flawed structural components	PO2, PO4	4
4	Assess the life of structural components under creep	PO2, PO4	4

Syllabus:

Analysis of stresses and strains in three-dimensions: Principal stresses and strains. Stress / strain invariants, Octahedral stresses, Theories of failure, various yield criteria.
Repeated Stresses and fatigue in metals: Fatigue tests, endurance limit, Fatigue under combined loadings. Fatigue design theory: Goodman, Gerber and Soderberg criteria.
Factors influencing fatigue behavior of metals: Frequency, temperature, size, form, surface conditions, residual stress, etc. influence of stress concentration, notch sensitivity. Various mechanical and metallurgical methods used for improving fatigue strength of metals. Effects of corrosion; Corrosion fatigue and fretting; Cumulative fatigue damage and life estimation of components;
Fracture Mechanics: Basic modes of fracture; Griffith theory of brittle fracture and Orwan modifications;
Linear Elastic Fracture Mechanics (LEFM): Stress field ahead of crack-tip; stress intensity factors; critical SIF; Fracture toughness testing and evaluation of KIC.
Elasto-plastic fracture mechanics: Plane stress and plane strain plastic zone sizes; J-integral method; SERR computation and evaluation of structural integrity.
Creep behaviour of metals: Creep-stress-time-temperature relations; creep testing methods; Mechanics of creep; creep in tension, bending and torsion; strain-hardening effects on creep; creep buckling; members subjected to combined stresses and creep.

Text books:

1. Mechanical Metallurgy – George E. Dieter (McGraw-Hill)
2. Elementary Engineering Fracture Mechanics – David Broek (Springer)

Reference Books:

1. Engineering Fracture Mechanics – S.A. Meguid (Springer)
2. Fracture Mechanics – C.T. Sun and Z.H. Jin (Elsevier)
3. Elements of Fracture Mechanics – Prashant Kumar (Tata McGraw-Hill)
4. Fundamentals of Fracture Mechanics – TribikramKundu (CRC Press)
5. Mechanical Behavior of Materials – Norman E. Dowling (Prentice Hall)

21ME4055 - ADVANCED STRENGTH OF MATERIALS

L-T-P-S : 2-0-2-0
Credits : 3
Contact Hours : 4
Pre-requisites : 22ME2101

Mapping of Course Outcomes with PO/PSO:

CO#	Course outcome	PO/PSO	BTL
CO1	Analyze statically indeterminate beams	PO1, PO2	4
CO2	Analyze stresses in curved beams and identify the Shear Centre for various cross sections of beams	PO1, PO2	4
CO3	Apply unit load method to find deflections in beams and structures	PO1, PO2	3
CO4	Analyze stresses in rotating members and thick cylinders	PO1, PO2	4
CO5	To simulate the structural members using ANSYS and validate the results with analytical methods	PO1, PO2	4

Syllabus:

Statically Indeterminate Beams: Introduction to Statically indeterminate Beams, apply the Moment Area Method to analyze the fixed beams. Introduction to Continuous beams, apply Clapeyron's theorem of three moments to analyze continuous beams.
Curved Beams: Stresses in Beams of small and large initial curvature, Winkler-Bach theory, Stresses in Crane Hook and C-Clamp with Rectangular, Circular and Trapezoidal cross-sections.
Shear Center: Importance of Shear Centre, Locate the shear center for different cross-sections.
Energy Methods: Introduction, Principles of virtual work, Apply Unit load Method to determine displacements and slope in Beams and to analyze simple structures and trusses.
Centrifugal Stresses: Introduction, Stresses in Rotating Ring, Disc of uniform thickness.
Thick Cylinders: Stresses in Thick cylinders, Apply Lame's theory to determine radial and circumferential stresses in thick cylinders. Stresses in compound cylinders.

Text books:

1. Mechanics of Materials by Gere and Timoshenko, CBS publishers, 2nd edition.

Reference Books:

1. Pytel A H and Singer F L, *"Strength of Materials",* Harper Collins, New Delhi.
2. Beer P F and Johston (Jr) E R, *"Mechanics of Materials",* SI Version, McGraw Hill, NY.
3. Popov E P, *"Engineering Mechanics of Solids",* SI Version, Prentice Hall, New Delhi.
4. Advanced Mechanics of Solids by L. S. Srinath, 3rd edition Tata McGraw-Hill, 2009.

List of Experiments:

1. To analyze fixed beam subjected to symmetrical loading
2. To analyze fixed beam subjected to unsymmetrical loading
3. To analyze two span continuous beam subjected to similar loads
4. To analyze three span continuous beam subjected to combination of loads
5. To analyze curved beam with rectangular cross section
6. To analyze curved beam with trapezoidal cross section
7. To validate the simulation of cantilever beam using analytical method
8. To validate the simulation of Truss using analytical method
9. To plot the variation of stresses in rotating disc of uniform thickness
10. To analyze thick cylinder subjected to internal pressure

21ME4056 - MECHANICS OF COMPOSITES

L-T-P-S : 2-0-2-0
Credits : 3
Contact Hours : 4
Pre-requisites : 22ME2208

Mapping of Course Outcomes with PO/PSO:

CO#	Course outcome	PO/PSO	BTL
CO1	Know the composite materials and manufacturing methods	PO1	2
CO2	Identify the behavior of composite Lamina at micro level	PO1	3
CO3	Identify the behavior of composite Lamina at macro level	PO1	3
CO4	Apply Failure theories to calculate stresses in composite materials	PO1, PS01	3

Syllabus:

Introduction to composite materials, Geometric definitions, Classification of composites, Types of fibers, Types of the matrix, Hybrid composite, scale of analysis- micro and macro mechanics approaches, Degree of Anisotropy. Manufacturing methods of the composites, Autoclave moulding, Filament winding, Resin transfer moulding.

Elastic behaviour of composite lamina (Micro mechanics), Micro mechanics methods, Geometric aspects and elastic symmetry, Longitudinal elastic properties (Continuous fibers), Transverse elastic properties, In-plane shear properties (Continuous fibers), Longitudinal properties (short fibers)

Elastic behaviour of composite lamina (Macro mechanics approach), stress strain relations: General anisotropic material, Specially orthotropic material, transversely isotropic material, Orthotropic material under plane stress, isotropic material.

Standard sizes of the specimen for tensile and compressive, Fatigue tests, impact test of uni-directional composites. Failure of the composite materials: fibre failures, matrix failure, interface failure. Failure Theories Tsai-Wu, Tsai-hill, Puck criterion, Maximum stress, maximum strain, Hashin.

Text Books:

1. Engineering Mechanics of composite materials by Issac Daniel
2. Mechanics of composite Materials by AutarK.Kaw

Reference Books:

1. Mechanics of composite materials by R.M.Jones
2. Mechanics of Composite Materials Recent Advances by ZviHashin, Carl T.Herakovich
3. Principles of composite material mechanics by Ronald F.Gibson

21ME4057 – SUSTAINABLE DESIGN & SOCIAL INNOVATION IN ENGINEERING DESIGN

L-T-P-S : 1-0-4-0
Credits : 3
Contact Hours : 5
Pre-requisites : NIL

Mapping of Course Outcomes with PO/PSO:

CO#	Course outcome	PO/PSO	BTL
CO1	apply all fundamental concepts related to the streams in Engineering Design Specialization	PO1	3
CO2	identify the real-world problem and inculcate problem solving and critical thinking skills	PO1	3
CO3	Develops a conceptual prototype on software tools	PO1	3
CO4	Design and execute a fully functional prototype	PO4, PSO2	6

Course Objective:

- The objective of this course is to design a capstone project by providing understanding of all necessary fundamental concepts learned through the core and elective courses and able to identify the real-world problem and provide the solution.

Syllabus:

Fundamental concepts in Engineering Design Specialization

Hands-on experience on all relevant software tools

Capstone Project:

Step-1: Define the problem and identify the objectives

Step-2: Research must be focused and incorporate new ideas and a thorough exploration of old similar ideas.

Step-3: The build process must take into consideration materials, processes, construction limitations, and cost**.**

Step-4: The entire project must be tested to see if it does the job for which it was designed.

References:

1. Text books
2. E-resources
3. Journals
4. Web resources

21ME4061 - MODERN MANUFACTURING PROCESSES

L-T-P-S : 2-0-2-0
Credits : 3
Contact Hours : 4
Pre-requisites : 22ME2107

Mapping of Course Outcomes with PO/PSO:

CO#	Course outcome	PO/PSO	BTL
CO1	understand the working principle and the effect of various process parameters of mechanical energy-based machining processes	PO2	2
CO2	understand the working principle and the effect of various process parameters of chemical and thermoelectric energy-based machining processes	PO2	2
CO3	understand the working principle and the effect of various process parameters on the performance of various Non-Traditional Welding Processes.	PO2	2
CO4	understand the working principle of various Non-Traditional Forming Processes.	PO2	2
CO5	Perform various non traditional manufacturing for product making	PO5	4

Syllabus:

Modern Manufacturing Processes: Introduction, Need for modern manufacturing processes. Classification of modern machining processes based on sources of energy.

Mechanical energy-based machining processes: Principle, Equipment, Process parameters, Advantages, limitations and applications of Abrasive jet machining, water jet machining, ultrasonic machining.

Chemical energy-based machining processes: Principle, Equipment, Process parameters, Advantages, limitations and applications of Chemical machining, Electro-chemical machining, Electro-chemical deburring and Electro chemical honing.

Thermoelectric energy-based machining processes: Principle, Equipment, Process parameters, Advantages, limitations and applications of Electric discharge machining, Wire-electric discharge machining, electric discharge grinding, laser beam machining, plasma arc machining, electron beam machining.

Non-traditional welding processes: Principle, Equipment, Process parameters, Advantages, limitations and applications of Laser beam welding, Plasma arc welding, Electron beam welding, Ultrasonic welding, Friction welding, Explosive welding and Under water welding.

Non-traditional Forming processes: Methods, advantages, limitations and applications of Explosion Forming Process, Electro Hydraulic Forming, Magnetic Pulse Forming, Petro-Forge Hammer.

Text Books:

1. Advanced machining processes / Jain V K / Allied Publishers, 2005
2. Welding and Welding Technology, Richard L. Little, McGraw Hill.Inc., U S,Ist Edition.

Reference Books:

1. Modern Machining Processes / Pandey P.C. and Shah H.S./ TMH, 1995
2. New Technology / Bhattacharya A/ The Institution of Engineers, India 1984
3. Production Technology -- H.M.T.
4. High velocity forming of metals -ASTME Prentice Hall
5. Non-Conventional Machining by P K Mishra, Narosa Publications

22ME4062 – MACHINE TO MACHINE COMMUNICATION

L-T-P-S : 2-0-2-0
Credits : 3
Contact Hours : 4
Pre-requisites : NIL

Mapping of CO-PO table:

CO#	Course outcome	PO/PSO	BTL
CO1	Understand the standards, protocols, and algorithms in M2M Communication .	PO2	2
CO2	Implement the M2M Communication protocols in a prototype.	PO1	3
CO3	Design new protocols for different scenarios.	PO2	5
CO4	Understand possible applications of M2M.	PO6	2

Syllabus:

Introduction to M2M, Description of M2M Market Segments/Applications – Automotive, Smart Telemetry, Surveillance and Security, M2M Industrial Automation.

ETSI M2M Services Architecture – Introduction, High-Level System Architecture, Introducing REST Architectural Style for M2M, Applying REST to M2M, Additional Functionalities.

ETSI TC M2M Resource-Based M2M Communication and Procedures - Resource Structure, Interface Procedures.

M2M over a Telecommunications Network - Mobile or Fixed Networks, Network Optimizations for M2M, 3GPP Standardization of Network Improvements for Machine Type Communications, 6LoWPAN.

M2M Terminals and Modules - Access Technology, Physical Form Factors, Hardware Interfaces, Power Interface, USB (Universal Serial Bus) Interface, UART (Universal Asynchronous Receiver/ Transmitter) Interface, Antenna Interface, UICC (Universal Integrated Circuit Card) Interface, GPIO (General-Purpose Input/Output Port) Interface, SPI (Serial Peripheral Interface) Interface, I2C (Inter-Integrated Circuit Bus) Interface, ADC (Analog-to Digital Converter) Interface, PCM (Pulse Code Modulation) Interface, PWM (Pulse Width Modulation) Interface, Software Interface, AT Commands, SDK Interface

Transportation & Automotive:
Possible M2M applications in the transportation and automotive sectors include, Vehicle driver performance, fuel consumption, GPS tracking, E-Toll, Prevention of Vehicle Theft, Traffic control, Smart Parking, Emergency call (eCall) etc.

Utilities:
M2M applications to monitor and control the generation, transmission, Distribution and consumption by employing intelligent devices.

- Smart meters – water, energy & fuel consumption for home & industry, smart grid – monitor load in real time, Electric Vehicle Charging Infrastructure are a few examples under this category.

Practice:

The experiments are designed as mini projects that make use of the architecture, services, and interfaces of the various M2M terminals and modules. Mini projects include Telemetry Surveillance E-Health vehicular communication Smart metering LoWPAN based networks

Text Books

1. D. Boswarthick, O. Elloumi, and O. Hersent, M2M communications: A systems approach, Wiley, 1st edition, 2012, ISBN: 978-1119994756.

Reference books:

1. J. Holler et al., From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence, Academic Press, 1st edition, 2014, ISBN: 978-0124076846.

2. C. Anton-Haro and M. Dohler, Machine-to-machine (M2M) Communications: Architecture, Performance and Applications, Woodhead Publishing, 1st edition, 2015, ISBN: 978-1782421023.

21ME4063 - ADVANCED MATERIALS

L-T-P-S : 3-0-0-0
Credits : 3
Contact Hours : 4
Pre-requisites : NIL

Mapping of Course Outcomes with PO/PSO:

CO#	Course outcome	PO/PSO	BTL
CO1	Understand various types of materials involved in manufacturing Composites.	PO1	2
CO2	Understand the importance of Bio, Smart and microelectronic materials.	PO4	2
CO3	Understand the significance of functionally graded materials and their applications.	PO4	2
CO4	Understand synthesis and fabrication methods of nanomaterial and to study characterisation techniques.	PO4	2

Syllabus:

ENGINEERING MATERIALS: Introduction
INTRODUCTION TO COMPOSITE MATERIALS: Introduction, classification: Polymer matrix composites, metal matrix composites, ceramic matrix composites, carbon–carbon composites, fiber-reinforced composites and nature-made composites, and applications.
MANUFACTURING METHODS: Hand layup, spray-up, filament winding, pultrusion, moulding method, RTM, Rule of mixtures.
BIO MATERIALS: Introduction, properties, applications, Biocompatibility, classification.
SMART MATERIALS: Introduction-shape memory effect- classification of shape memory alloys-composition-properties and applications of shape memory alloys.
MICROELECTRONIC MATERIALS: Introduction, properties of Silicon, silicon wafer production, Lithography technique.
FUNCTIONALLY GRADED MATERIALS: Types of functionally graded materials-classification-different systems-preparation-properties and applications of functionally graded materials.
NANO MATERIALS: Introduction-properties at nano scales-advantages & disadvantages-applications in comparison with bulk materials (nano – structure, wires, tubes, composites).
Elements of Nanoscience and Nanotechnology: Synthesis of nanomaterials, fabrication and characterization of nanostructures, applications. Material processing by chemical vapor deposition and physical vapor deposition–Principle of SEM, TEM, AFM.
Materials Characterisation:
X-ray diffraction, Neutron diffraction and Electron diffraction–X-ray fluorescence spectroscopy–Fourier transform Infrared spectroscopy (FTIR)–Ultraviolet and visible spectroscopy (UV-Vis)–Thermogravimetric Analysis (TGA)–Differential Thermal Analysis (DTA)–Differential Scanning Calorimetry (DSC).

Text Book:

1. Nano material by A.K. Bandyopadyay, New age Publishers.
2. Material science and Technology- Cahan.
3. Engineering Mechanics of Composite Materials by Isaac and M Daniel, Oxford University Press.

Reference Books:

1. R. M. Jones, Mechanics of Composite Materials, McGraw Hill Company, New York, 1975.
2. L. R. Calcote, Analysis of Laminated Composite Structures, Van-NostrandRainfold.
3. B. D. Agarwal and L. J. Broutman, Analysis and performance of fibre Composites, Wiley-Interscience, New York, 1980.
4. Mechanics of Composite Materials, Second Edition (Mechanical Engineering), AutarK.Kaw, Publisher: CRC.

21ME4064 - FLEXIBLE MANUFACTURING SYSTEMS

L-T-P-S : 2-0-2-0
Credits : 3
Contact Hours : 4
Pre-requisites : Nil

Mapping of Course Outcomes with PO/PSO:

CO#	Course outcome	PO/PSO	BTL
CO1	Analyze various production schedules and plant layouts.	PO2	3
CO2	Apply the concept of group technology to the development of FMS.	PO2	3
CO3	Identify hardware and software components of FMS.	PO2	3
CO4	Analyze materials handling and storage system in FMS.	PO2	3
CO5	Implement NC part programming in part production	PO4	3

Syllabus:

Production systems: Types of production-Job Shop, Batch and Mass production-Functions in manufacturing - Organization and information processing in manufacturing - Plant layout - Work in progress inventory - Scheduling, problems.

Group technology: Formation of part families - Part classification - Coding system - Opitz, Multi Class, Production flow analysis - Machine cell design - Clustering methods - Modern algorithms - Benefits - System planning - Objective, guide line, system definition and sizing - Human resources - Objective, staffing, supervisor role.

Flexible manufacturing systems: FMS - Introduction - Evolution - Definition - Need - Economic Justification, Application - Machine tool Selection and Layout - Computer control system - Data files - Reports - Planning the FMS - Analysis Methods for FMS - Benefits and limitations.

Flexible manufacturing cells: Introduction - Cell description and classifications - Unattended machining – Component handling and storage system - Cellular versus FMS - System - Simulation, Hardware configuration - Controllers - Communication networks - Lean production and agile manufacturing.

Text Books:

1. William W. Luggen, “Flexible Manufacturing Cells and Systems”, Prentice Hall, New Jersey, 1991.
2. Mikell P. Groover, “Automation Production Systems & Computer Integrated manufacturing”, Prentice Hall of India, New Delhi, 2007.
3. Jha.N.K, "Handbook of Flexible Manufacturing Systems", Academic Press Inc., 1991.

Reference Books:

1. David J. Parrish, “Flexible Manufacturing”, Butterworth-Heinemann, Newton, MA, USA, 1990.
2. Radhakrishnan.P and Subramanyan.S, “CAD/CAM/CIM”, Wiley Eastern Ltd., New Age International Ltd., 1994.
3. Raouf.A and Ben-Daya.M, Editors, “Flexible manufacturing systems: recent development”, Elsevier Science, 1995.

21ME4065 - ROBOTICS & INDUSTRIAL AUTOMATION

L-T-P-S : 2-0-2-0
Credits : 3
Contact Hours : 4
Pre-requisites : Nil

Mapping of Course Outcomes with PO/PSO:

CO#	Course outcome	PO/PSO	BTL
CO1	Identify role of robotics in Industrial Automation	PO3	2
CO2	Identify Safety in Industrial Automation	PO3	2
CO3	Identify and understand the types of Industrial Sensors	PO3	2
CO4	Identify Practical Programmable Logic Controller Applications	PO3	2

Syllabus:

Evolution of Robotics and Automation: Robotics in science fiction, industrial revolution, history and need of robotics, definition of a robot, robot terminology, types and applications of robot, overview of present status and future trends, robotics market and future prospects.

Industrial Automation: Reasons for automation, arguments for and against automation, type of Industries and components of automation.

Types of Industrial Sensors: Optical, Inductive, Capacitive, Encoders, Ultrasonic, Thermocouples, Demonstrate Proper Wiring Techniques and Practical Applications.

Programmable Logic Controller: Introduction to PLC, Need of PLC in Designing, Architecture of PLC, Application and Advantage of PLC, Automation Concept and Basic Design, PLC Programming.

Text Books:

1. Terry Bartlet, “Industrial Control Electronics Devices, Systems, & Applications”, 3rd Edition, Delmar Publisher.

22ME4066 - REVERSE ENGINEERING AND RAPID PROTOTYPING

L-T-P-S : 2-0-2-0
Credits : 3
Contact Hours : 4
Pre-requisites : Nil

Mapping of CO-PO table:

CO#	Course outcome	PO/PSO	BTL
CO1	Use the Digitized Shape Editor (DSE) workbench	PO2	2
CO2	Import and process the digitized data (scans or clouds of points),	PO1	3
CO3	Quick Surface Reconstruction (QSR) from the digitized data.	PO2	3
CO4	Create a mesh and extract characteristic curves to create surfaces using point cloud data	PO6	6

Syllabus:

Introduction to Reverse Engineering

Historical Background & Industrial Evolution,Reverse Engineering in Modern Industries, Motivation and Challenge, Analysis and Verification, Applications of Reverse Engineering & 3D scanning.

Practice :1 Generate a Model from a Product

Processing the Point data & Creating Tessellated Mesh

Stages in the Process, Introduction to Digitized shape editor, Importing the Point data, editing the cloud, Creating & Correcting the mesh, editing the mesh, creating tessellated mesh

Practice:2 Cloud Point Generation

Practice :3 Mesh Generation from Cloud Point data

Curve Creation & Processing

Stages in the Process, creating and editing scans, creating curves, Additional tools, Introduction to quick surface reconstruction, creating scans by segmentation, processing curves

Practice : 4 Curve Generation

Creating Surface

Stages in the Process, creating surface, using automatic processes, checking deviations

Practice :5 Surface Generation & Optimization

Additive Manufacturing

Additive Manufacturing Technology in product development-Materials for Additive Manufacturing Technology,Classification – Stereo lithography Apparatus (SLA)- Principle, process, advantages – Fused Deposition Modeling – Principle, process, advantages.Selective Laser Sintering – Principle, Process, advantages, Three Dimensional Printing – Principle, process, advantages - Laser Engineered Net Shaping (LENS)

Delmia Additive Part Preparation Essentials

Preparing Infrastructure, Preparing Parts, Managing Rules, Generating the Slicing Path,

Practice : 6 Prepare a part for 3D Printing

Master Project

Reverse Engineering of the Car Fender and 3D Printing

Text Books

1. Dassault Systemes Companion Learning Space : Catia Reverse Engineering Essentials
2. Rapid Prototyping: Principles and Applications in Manufacturing by Chua Chee Kai and Leong Kah Fai, JohnWiley & Sons.
3. Stereo-lithography and Other RP&M Technologies from Rapid prototyping to rapid tooling by Paul F Jacobs,SME/ASME.

Reference books:

1. Virtual Reality Systems by John Vince, Addison-Wesley.
2. Garage Virtual Reality by Linda Jacobson, Sams Publishing.

21ME4067 – SUSTAINABLE DESIGN & SOCIAL INNOVATION IN SMART MANUFACTURING

L-T-P-S : 1-0-4-0
Credits : 3
Contact Hours : 5
Pre-requisites : NIL

Mapping of Course Outcomes with PO/PSO:

CO#	Course outcome	PO/PSO	BTL
CO1	apply all fundamental concepts related to the streams in smart manufacturing Specialization	PO1	3
CO2	identify the real-world problem and inculcate problem solving and critical thinking skills	PO1	3
CO3	Develop a conceptual prototype	PO1	3
CO4	Design and execute a fully functional prototype	PO4, PSO1	5

Course Objective:

- The objective of this course is to design a capstone project by providing understanding of all necessary fundamental concepts learned through the core and elective courses and able to identify the real-world problem and provide the solution.

Syllabus:

Fundamental concepts in Smart Manufacturing Specialization

Hands-on experience on all relevant software tools

Capstone Project:

Step-1: Define the problem and identify the objectives

Step-2: Research must be focused and incorporate new ideas and a thorough exploration of old similar ideas.

Step-3: The build process must take into consideration materials, processes, construction limitations, and cost**.**

Step-4: The entire project must be tested to see if it does the job for which it was designed.

References:

1. Text books
2. E-resources
3. Journals
4. Web resources

21ME4071-HYDROGEN AND FUEL CELL TECHNOLOGIES

L-T-P-S : 2-0-2-0

Credits: 3

Pre Requisite: Nil

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand various properties of hydrogen and various production methods	PO1	2
CO2	Understand hydrogen storage methods and employing hydrogen as fuel for IC engine	PO1	2
CO3	Understand fuel cell basics and Fuel cell thermodynamics	PO1	2
CO4	Understand fuel cell reaction kinetics	PO1	2
CO5	Analyze various hydrogen systems and fuel cells using Trnsys and COMSOL Multiphysics	PO5	4

Syllabus:

Hydrogen basics and Production methods: Hydrogen – physical and chemical properties, salient characteristics. Production of hydrogen – steam reforming water electrolysis – gasification and woody biomass conversion – biological hydrogen production –photo dissociation – direct thermal or catalytic splitting of water

Hydrogen storage methods: Hydrogen storage options – compressed gas – liquid hydrogen – Hydride – chemical Storage – comparisons. Safety and management of hydrogen, Transportation of hydrogen. Applications of Hydrogen.

Hydrogen as a fuel for automobiles – Combustive properties of Hydrogen, Problems caused by hydrogen by employing fuel for automobiles, Design modifications required for the engine, Performance parameters of hydrogen fuelled IC engines.

Fuel cell: Overview of Fuel Cells, low and high temperature fuel cells. Fuel Cell performance, Polymer electrolyte fuel cells, Alkaline fuel cells, Phosphoric fuel cells, Molten carbonate fuel cells, Solid oxide fuel cells, Fuel cell systems and Sample calculations.

Fuel cell thermodynamics - heat, work potentials, prediction of reversible voltage, fuel cell efficiency.

Fuel cell reaction kinetics - electrode kinetics, over voltages, Tafel equation, charge transfer reaction, exchange currents, electrocatalyses - design, activation kinetics, Fuel cell charge and mass transport - flow field, transport in electrode and electrolyte.

Experiments:

- Analysis of hydrogen production using Electrolyzer
- Analysis of hydrogen storage system
- Modelling of fuel cell
- Optimization of fuel cell membrane thickness
- Analysis of PEM fuel cell
- Analysis of Solid Oxide fuel cell
- Modelling of Fuel cell electric vehicle
- Analysis of Fuel cell electric vehicle
- Design of an integrated photovoltaic electrolyzer
- Porous electrode optimization for an integrated photovoltaic electrolyzer

Recommended Books

1. Viswanathan, B and M Aulice Scibioh, Fuel Cells – Principles and Applications, Universities Press(2006)
2. Rebecca L. and Busby, Hydrogen and Fuel Cells: A Comprehensive Guide, Penn Well Corporation,Oklahoma (2005
3. Bent Sorensen (Sørensen), Hydrogen and Fuel Cells: Emerging Technologies and Applications, Elsevier,UK (2005)
4. Kordesch, K and G.Simader, Fuel Cell and Their Applications, Wiley-Vch, Germany (1996)
5. Hart, A.B and G.J.Womack, Fuel Cells: Theory and Application, Prentice Hall, NewYork Ltd.,London (1989)
6. Jeremy Rifkin, The Hydrogen Economy, Penguin Group, USA (2002).

21ME4072-SOLAR ENERGY TECHNOLOGIES

L-T-P-S : 2-0-2-0

Credits: 3

Pre requisite:Nil

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand the basics of solar radiation and working principle of various solar collectors	PO2	2
CO2	Understand the working of solar thermal systems	PO2	2
CO3	Understand the fundamentals of Solar PV technology	PO2	2
CO4	Apply the knowledge of thermodynamics and heat transfer to calculate the performance of solar PV systems	PO2	3
CO5	Analyze various solar thermal and PV systems using TRNSYS software	PO5	4

Syllabus:

Solar Radiation and collectors: Solar angles – Sun path diagrams – Radiation - extraterrestrial characteristics - measurement and estimation on horizontal and tilted surfaces - flat plate collector thermal analysis - testing methods- evacuated tubular collectors - concentrator collectors – classification - design and performance parameters- tracking systems - compound parabolic concentrators - parabolic trough concentrators - concentrators with point focus - Heliostats – performance of the collectors

Solar Thermal Systems: Principle of working, types, design and operation of - Solar heating and cooling systems – Thermal Energy storage systems – Solar Desalination – Solar cooker : domestic, community – Solar pond – Solar drying

Solar PV fundamentals – Semiconductor – properties - energy levels - basic equations of semiconductor devices physics. Solar cells - p-n junction: homo and hetero junctions - metal-semiconductor interface - dark and illumination characteristics - figure of merits of solar cell - efficiency limits - variation of efficiency with band-gap and temperature - efficiency measurements - high efficiency cells – Solar thermo-photovoltaics.

Analysis of Solar PV Systems: Solar cell array system analysis and performance prediction-Shadow analysis: reliability - solar cell array design concepts - PV system design - design process and optimization - detailed array design - storage autonomy - voltage regulation - maximum tracking - centralized and decentralized SPVsystems - stand alone - hybrid and grid connected system - System installation - operation and maintenances - field experience - PV

market analysis and economics of SPV systems

Experiments:

- Analysis of flat plate and parabolic trough arrays
- Simulation and analysis of solar radiation over flat plate solar collector
- Simulation and analysis of solar radiation over parabolic solar collector
- Analysis of solar water heater
- Analysis of CPC collector
- Analysis of Evacuated Tube collector
- Performance estimation of direct solar still
- Performance estimation of indirect solar still
- Integration of PV cell and battery
- Analysis of sensible heat storage device

Recommended Books

1. Goswami, D.Y., Kreider, J. F. and & Francis., Principles of Solar Engineering, Taylor and Francis,2000
2. Chetan Singh Solanki, Solar Photovoltatics – Fundamentals, Technologies and Applications, PHILearning Private limited, 2011
3. Sukhatme S P, J K Nayak, Solar Energy – Principle of Thermal Storage and collection, TataMcGrawHill, 2008.
4. Solar Energy International, Photovoltaic – Design and Installation Manual – New SocietyPublishers, 2006
5. Roger Messenger and Jerry Vnetre, Photovoltaic Systems Engineering, CRC Press, 2010.

22ME4073-ADVANCED ENERGY STORAGE SYSTEMS

L-T-P-S : 2-0-2-0

Credits: 3

Pre Requisite: Nil

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand the basics of Energy storage systems and its applications	PO1	2
CO2	Modelling of various thermal energy storage systems	PO2	4
CO3	Understand the construction and working of various electrical storage systems	PO1	2
CO4	Understand the principles of alternate energy storage technologies	PO1	2
CO5	Analyze various energy storage systems using MATLAB/Simulink	PO5	4

Syllabus:

Introduction: Necessity of energy storage – types of energy storage – comparison of energy storage technologies – Applications

Applications of Energy Storage: Renewable energy storage-Battery sizing and stand-alone applications, stationary (Power Grid application), Small scale application-Portable storage systems and medical devices, Mobile storage Applications.

Modelling of thermal energy storage systems: Thermal storage – Types – Modelling of thermal storage units – Simple water and rock bed storage system – pressurized water storage system – Modelling of phase change storage system – Simple units, packed bed storage units - Modelling using porous medium approach.

Electrical Energy storage systems – Fundamental concept of batteries – measuring of battery performance, charging and discharging of a battery, storage density, energy density, and safety issues. Types of batteries – Lead Acid, Nickel –Cadmium, Zinc Manganese dioxide and modern batteries for example (i) zinc-Air (ii) Nickel Hydride,
(iii) Lithium Battery. Application to EVs.

Alternate energy storage technologies: Flywheel, Super capacitors, Principles & Methods – Applications, Compressed air Energy storage, Concept of Hybrid Storage – Applications

Experiments:

- Modelling of Li ion battery

- Performance Analysis of Li ion battery
- Thermal management of battery pack
- Structural reliability of a battery pack
- Thermal analysis of sensible heat storage unit
- Analysis of packed bed storage system
- Modelling and analysis of energy storage unit through porous medium approach
- Simulation of ice based latent heat thermal energy storage
- Modelling of supercapacitor
- Analysis of supercapacitor

Recommended Books

1. Ibrahim Dincer and Mark A. Rosen, Thermal Energy Storage Systems and Applications, JohnWiley & Sons 2002
2. Fuel cell systems Explained, James Larminie and Andrew Dicks, Wiley publications, 2003.
3. Electrochemical technologies for energy storage and conversion, Ru-shiliu, Leizhang, Xueliangsun,

22ME4074- ENERGY AUDIT AND MANAGEMENT

L-T-P-S : 3-0-0-0

Credits: 3

Pre Requisite: Nil

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand the fundamentals of Energy economics	PO1	2
CO2	Apply the Engineering principles to estimate the energy conservation in steam generators and compressed air generators	PO2	3
CO3	Apply the Engineering principles to estimate the energy conservation in rotary equipment, Refrigeration & Air conditioning systems	PO2	3
CO4	Apply the Engineering principles to estimate the energy conservation in cooling towers and lighting systems	PO2	3

Syllabus:

Energy Scenario – Energy Conservation Act - Role of Energy Managers in Industries – Energy monitoring, auditing & targeting – Economics of various Energy Conservation schemes.

Energy Economics - Simple Payback Period, Time Value of Money, IRR, NPV, Life Cycle Costing, Cost of Saved Energy, Cost of Energy generated, Examples from energy generation and conservation.

Steam Generation, Distribution and Utilization - Boilers - types, losses and efficiency calculation methods. Steam traps. Insulation. Boiler controls. Various Energy Conservation Measures in Steam system.

Compressed Air Generation, Distribution and Utilization - Cost of compressed air – No load test - Various Energy Conservation Measures in compressed air system – Case studies.

Energy Conservation Opportunities Rotary Equipment - Centrifugal pumps, Fans & Blowers.

Refrigeration & Air conditioning – Definition of HVAC – Cooling load calculations (preliminary estimates only) – Introduction to Building Management System - Energy Conservation Opportunities – Case studies.

Energy conservation in cooling towers – Analysis and Case studies.

Energy conservation in Lighting – Analysis and Case studies.

Visit to energy generation / consumption facility. [Visiting nearest Thermal Power Station and a Milk Dairy]

Recommended Books:

1. Eastop, T. D. and Croft, D. R., Energy Efficiency for Engineers and Technologists, Longman Scientific & Technical, ISBN-0-582-03184, 1990.

2. Reay D.A, Industrial Energy Conservation, 1stedition, Pergamon Press, 1977.

3. Bureau of Energy Efficiency - Energy Management Series

4. Larry C. Whitetail, Industrial Energy Management & Utilization

22ME4075-COMPUTATIONAL FLUID FLOW AND HEAT TRANSFER – FDM APPROACH

L-T-P-S : 2-0-2-0

Credits: 3

Prerequisite: 22ME2105, 22ME2106.

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand the basics of PDE and FDM	PO2	2
CO2	Apply FDM to Steady one- and two-dimensional heat conduction equations	PO2	3
CO3	Apply FDM to Unsteady one- and two-dimensional heat conduction equations	PO2	3
CO4	Understand the modified equations of FD formulation	PO2	2
CO5	Development of codes for various fluid flow and heat transfer problems in C++/Matlab following FDM	PO4	4

Syllabus:

Introduction: Brief introduction of ODE (IVP and BVP) and PDE, Initial and Boundary conditions, classification of PDE, various methods to solve PDE numerically along with their advantages and disadvantages.

FDM: Taylor series expansion, Finite difference equations (FDE) of 1st, and 2nd order derivatives, Truncation errors, order of accuracy.

Aspects of FDE: Convergence, consistency, explicit, implicit and C-N methods.

Application of FDM: Steady and unsteady one- and two-dimensional heat conduction equations, one-dimensional wave equations, General method to construct FDE

Solution of simultaneous equations: direct and iterative methods; Jacobi and various Gauss-Seidel methods (PSOR, LSOR and ADI), Gauss-elimination, TDMA (Thomas), Gauss-Jordan, other direct and indirect methods.

Errors and Stability of FDE: Diffusion and dispersion errors Stability of 1D and 2D diffusion equation, 1D wave equation (FTCS, FTBS and FTFS).

Modified equations of FD formulation: Diffusion and dispersion errors of modified equation (wave equation) having second and third order derivatives, modified wave number and modified speed.

Upwinding: Upwinding of convective terms and its significance, Transportive and conservative properties. Upwind biased difference schemes and its significance.

Experiments:

- Solution of linear system of equation using Gauss – seidel and Jacobi method
- Development of TDMA solver
- 1D heat conduction with different boundary conditions
- Analysis of fin characteristics
- Solution of 1D parabolic partial differential equation with explicit time marching

- Solution of 1D parabolic partial differential equation with implicit time marching
- Solution of elliptic PDE
- Solution of convection – diffusion equation
- Solution of hyperbolic PDE

Recommended Books:

- Numerical Heat Transfer and Fluid Flow by S. V. Patankar (Hemisphere Series on Computational Methods in Mechanics and Thermal Science)
- Essential Computational Fluid Dynamics by Zikanov.O., Wiley 2010.
- Computational Fluid Dynamics by Chung T. J., Cambridge University Press, 2003.

21ME4076-CFD FOR COMPRESSIBLE AND INCOMPRESSIBLE FLOWS

L-T-P-S : 2-0-2-0

Credits: 3

Prerequisite: 22ME2105, 22ME2106 22ME3115, 22ME4104

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand the basics of various convective schemes, FVM discretization	PO2	2
CO2	Solve N-S equations for incompressible flows using stream function – vorticity formulation and Pressure-velocity coupled algorithms	PO2	3
CO3	Solve N-S equations for compressible flows using MacCormack, Jameson algorithm	PO2	3
CO4	Understand turbulence modelling	PO2	2
CO5	Analyze various fluid flow and heat transfer problems using Matlab programming/Ansys – Fluent following FVM	PO5	4

Syllabus:

Introduction: Brief introduction of boundary layer flow, incompressible and compressible flows, finite volume method, example of parabolic and hyperbolic systems and time discretization technique, explicit and implicit methods, upwind and central difference schemes, stability, dissipation and dispersion errors. Higher order upwind schemes: second order convective schemes, QUICK.

Incompressible Flow:

Solution of NS equations: Solution of incompressible N-S equation (Explicit time stepping, Semi–explicit time stepping).

Stream function-vorticity approach: Derivation of stream function and vorticity equations; derivation pressure Poisson equation.

Semi–implicit method (SIMPLE): algorithm for semi–implicit method, discussion on SIMPLE/SIMPLER and SIMPLEC. Discretization of governing equations and boundary conditions in FVM framework.

SMAC method for collocated grid: Pressure–velocity coupling, N- S equations on a collocated grid, concept of momentum interpolation to avoid pressure velocity decoupling, discretization of governing equations using the concept of momentum interpolation.

Compressible Flow:

N-S and energy equations, properties of Euler equation, linearization.

Solution of Euler equation: Explicit and implicit treatment such as Lax-Wendroff, MacCormark, Beam and Warming schemes, Upwind schemes for Euler equation: Steger and Warming, Van Leer's flux splitting, Roe's approximate Riemann solver, TVD schemes.

Solution of N-S equations: MacCormack, Jameson algorithm in finite volume formulation and transformed coordinate system.

Turbulence modelling:

Introduction to turbulence, scales of turbulence, Reynolds Averaged Navier Stokes (RANS) equation, closure problem, eddy viscosity model, k-ε and k-ω model, introduction to large eddy simulation (LES) and direct numerical simulation.

Experiments

- Development of algorithm for stream function - vorticity formulation
- Development of SIMPLE algorithm for a lid driven cavity on collocated grid.
- Development of SIMPLE algorithm for a lid driven cavity on staggered grid.
- Analysis of buoyancy induced flow.
- Analysis of transient natural convection
- Analysis of conjugate heat transfer problem
- Simulation and analysis of compressible flow through a convergent nozzle
- Determination of lift and drag for a symmetrical aerofoil
- Determination of lift and drag for a cambered aerofoil
- Determination of lift and drag, pressure distribution over a smooth cylinder

Recommended Books

1. *Computational Fluid Flow and Heat Transfer, Second Edition,* K. Muralidhar,T. Sundararajan (Narosa), 2011.
2. *Computational Fluid Dynamics,* Chung T. J., Cambridge University Press, 2003.
3. *Computational Fluid Dynamics,* Tapan K. Sengupta, University Press, 2005
4. *Numerical Computation of Internal and External Flows,* Hirch C., Elesvier 2007
5. *Numerical Heat Transfer and Fluid Flow,* S. V. Patankar (Hemisphere Series on Computational Methods in Mechanics and Thermal Science)
6. *Essential Computational Fluid Dynamics,* Zikanov. O., Wiley 2010.
7. *Computer Simulation of Flow and Heat Transfer,* P. S. Ghoshdastidar (4th Edition, Tata McGraw-Hill), 1998.

22ME4077-THERMAL MANAGEMENT OF ELECTRIC AND ELECTRONIC SYSTEMS

L-T-P-S:3-0-0-0
CREDITS:3
Pre Requisite: Nil

CO#	Course Outcome	PO/PSO	BTL
CO1	Apply the concepts of heat transfer to various electric and electronic systems requiring heat dissipation	PO1-2	3
CO2	Apply different cooling techniques to microchannels, heat pipes and vapor chambers	PO1-2	3
CO3	Apply various thermal management techniques in the fields of automobiles and electronics	PO1-2	3
CO4	Analyze the Battery thermal management system and battery pack design	PO2-1	4

Syllabus:

Introduction to Thermal Management in Electronics -heat transfer modes, electronics packaging, contact and spreading resistances, heat sink design, thermal interface material(TIM)

Cooling Technologies-thermal interface and phase change materials, active, passive and novel air cooling approaches, microchannels, jet impingement, immersion cooling, heat pipes and vapor chambers, thermoelectric

Applications of thermal management: avionics, data centers, mobile, internet of things, high-performance computing, automotive, etc

Lithium-ion battery configuration and operation, Sources of heat in Lithium-ion battery, Lithium Ion-cell temperature ranges. Battery Thermal Management System (BTMS): Need of BTMS, Technologies of BTMS, Battery pack design.

.

TEXT BOOKS:

T.L. Bergman, A.S. Lavine, F.P. Incropera, D.P. DeWitt, Fundamentals of Heat and Mass Transfer, Wiley, 2011)

22ME4081-ROBOT MOTION, PLANNING DYNAMICS & CONTROL

L-T-P-S : 3-0-0-0
Credits : 3
ContactHours : 3
Pre-requisite :NIL

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand the key concepts of robot motion generation.	PO1/PSO1	2
CO2	Apply motion of robot in the presence of obstacles	PO2/PSO1	3
CO3	Analyze motion planning and control	PO3/PSO1	4
CO4	Perform basic motion, force, and hybrid motion-force control.	PO2/PSO1	3

Syllabus:

Robot Motion Planning and Control: key concepts of robot motion generation: planning a motion for a robot in the presence of obstacles, and real-time feedback control to track the planned motion.

Motion Planning: foundational material like C-space obstacles, graphs and trees, and graph search, as well as classical and modern motion planning techniques, such as grid-based motion planning, randomized sampling-based planners, and virtual potential fields.

Robot Control: motion control, force control, and hybrid motion-force control.

Text Books:

1. MODERN ROBOTICS MECHANICS, PLANNING, AND CONTROL, Kevin M. Lynch and Frank C. Park, Cambridge University Press in May 2017.
2. Introduction to Autonomous Mobile Robots, By Roland Siegwart, Illah Reza Nourbakhsh, Davide Scaramuzza · 2011

22ME4082-ROBOT MANIPULATION & WHEELED MOBILE ROBOTS

L-T-P-S : 3-0-0-0
Credits : 3
ContactHours : 3
Pre-requisite :NIL

CO#	Course Outcome	PO/PSO	BTL
CO1	Determine various contact kinematics of robot manipulator	PO1/PSO1	2
CO2	Analyze contact forces and friction on the performance of manipulator	PO2/PSO1	4
CO3	Apply basic principles used in wheeled mobile robots.	PO3/PSO1	3
CO4	Understand odometry and mobile manipulation	PO2/PSO1	2

SYLLABUS:

Grasping and Manipulation:

Contact Kinematics: First-Order analysis of a Single contact, contact types: Rolling, Sliding, and Breaking free, Multiple contacts, Collection of Bodies, Other types of contacts, Planar Graphical Methods, Form Closure. Contact Forces and Friction: Friction, planar graphical methods, force closure, Duality of force and motion freedoms, manipulation.

Wheeled Mobile Robots:

Types of wheeled mobile robots, Omnidirectional wheeled mobile robots, modelling, motion planning, feedback control, nonholonomic wheeled mobile robots, modelling, Controllability, motion planning, and feedback control of odometry for wheeled mobile robots; and mobile manipulation.

Text Books:

3. MODERN ROBOTICS MECHANICS, PLANNING, AND CONTROL, Kevin M. Lynch and Frank C. Park, Cambridge University Press in May 2017.
4. Introduction to Autonomous Mobile Robots, By Roland Siegwart, Illah Reza Nourbakhsh, Davide Scaramuzza · 2011

22ME4083-MECHATRONICS: FUNDAMENTALS & CORE CONCEPTS

L-T-P-S : 3-0-0-0
Credits : 3
ContactHours : 3
Pre-requisite :NIL

CO#	Course Outcome	PO/PSO	BTL
CO1	Analyze mechatronics in manufacturing and distinguish between traditional and mechatronics approaches	PO1, PSO1	4
CO2	Be proficient in the use of Data conversion devices and Microprocessors controllers.	PO1, PSO1	1
CO3	Be able to analyze and select suitable drives and mechanisms for industrial applications	PO1, PSO1	4
CO4	Design and analyze the Hydraulic systems and understand PID controllers and CNC machines.	PO1, PSO1	4

Syllabus:

Module I: Introduction, Definition of Mechatronics, Mechatronics in manufacturing, products and design, Comparison between traditional and Mechatronics approach

Module II: Review of fundamentals of electronics, Data conversion devices, sensors, microsensors, trasducers, signal processing devices, relays, contactors and timers. Microprocessors controllers and PLCs.

Module III: Drives: Stepper motors, servo drives. Ball screws, linear motion bearings, cams, systems controlled by camshafts, electronic cams, indexing mechanisms, tool magazines, and transfer systems.

Module IV: Hydraulic systems: flow, pressure and direction control valves, actuators, and supporting elements, hydraulic power packs, and pumps. Design of hydraulic system components and graphic representations, design of systems.

Module V: Description of PID controllers. CNC machines and part programming. Industrial Robotics.

Recommended Text Books:

1. HMT ltd. Mechatronics, Tata Mcgraw-Hill, New Delhi, 1988
2. G.W.Kurtz, J.K.Schueller, P.W. Claar, Machine design for mobile and industrial applications, SAE, 1994.
3. T.O.Boucher, Computer automation in manufacturing-an introduction, Chappman and Hall, 1996.
4. R. Iserman, Mechatronic Systems: Fundamentals, Springer, 1st Edition,2005.
5. Musa Jouaneh, Fundamentals of Mechatronics, 1st Edition, Cengage Learning, 2012.

22ME4084-ARTIFICIAL INTELLIGENCE FOR ROBOTICS

L-T-P-S : 2-0-2-0
Credits : 3
ContactHours : 3
Pre-requisite :NIL

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand the concepts of AI	PO1/PSO1	2
CO2	Apply basic principles of AI in solutions that require problem- solving	PO2/PSO1	3
CO3	Apply basic principles of AI in solutions that require planning	PO3/PSO1	3
CO4	Analyze AI in Robotics	PO2/PSO1	4
CO5	Apply the theoretical concepts to conduct various experiments on Search Techniques and Language Representation using AI	PO5/PSO1	3

Syllabus :

Introduction: History, state of the art, Need for AI in Robotics. Thinking and acting humanly, intelligent agents, structure of agents, Turing Test, State space search - Un informed search.

Problem Solving: Solving problems by searching –Informed search and exploration–Constraint satisfaction problems–Adversarial search, knowledge and reasoning–knowledge representation – first order logic.

Planning: Planning with forward and backward State space search –Goal Stack Planning, Plan Space Planning, Partial order planning – Planning graphs–Planning with propositional logic – Planning and acting in real world.

AI in Robotics: Robotic perception, localization, mapping- configuring space, planning uncertain movements, dynamics and control of movement, Ethics and risks of artificial intelligence in robotics

Text Books :1.Stuart Russell, Peter Norvig, "Artificial Intelligence: A modern approach", Pearson Education, India. 2.Negnevitsky, M, "Artificial Intelligence: A guide to Intelligent Systems", Harlow: Addison-Wesley

Reference Books :1. David Jefferis, "Artificial Intelligence: Robotics and Machine Evolution", Crabtree Publishing Company.

List of Experiments

1. Write a program to implement depth first search algorithm.
2. Write a python program to implement Breadth First Search Traversal
3. (a). Write a program to simulate 4-Queen / N-Queen problem
   (b). Write a python program to implement simple Chatbot?
4. Write a program to solve tower of Hanoi problem.

5. Write a program to implement Hangman game using python.

6. Write a program for Hill climbing problem.

7. Write a python program to implement Water Jug Problem

21EC3075-HUMAN MACHINE INTERFACE & BRAIN MACHINE INTERFACE

L-T-P-S : 3-0-0-0
Credits : 3
ContactHours : 3
Pre-requisite :NIL

Mapping of Course Outcomes to Program outcomes:

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand the Basic Idea of Human Machine Interactions, and its Goals	**1**	**2**
CO2	Describe typical human–computer interaction (HCI) models, styles, and various historic HCI paradigms	**1**	**2**
CO3	Understand the Basic Idea of Brain Machine Interactions, and brain waves	**1,2**	**2**
CO4	Apply an interactive design process and universal design principles to designing HCI/BMI systems	**1,2**	**3**

Syllabus:

Intro. to HMI: Asimov's Laws, GUI Design, Aesthetics, Developments in Bio-Chips, Heuristics Introduction to the course and to HMI/HCI, HMI/HCI Its history Relation to Ergonomics and Human Factors Problems and challenges Recurrent HMI Themes, Historical evolution of the field, Concept of usability - definition and elaboration, HCI and software engineering, GUI design and aesthetics, Prototyping techniques

HMI Tech: GMOS Models, CMN-GOMS, Fitts laws, Hick-Hyman laws, Norman's 7 principles: (Design rules Authority vs. generality Principles, introduction to different types of models, GOMS family of models (KLM and CMN-GOMS, Fitts' law and Hick-Hyman's law, Guidelines in HCI: Norman's seven principles, Norman's model of interaction, Heuristic evaluation, Contextual inquiry, Cognitive walkthrough.

Brainwaves & BMI: Alpha, Beta, Theta, Gamma wave, Brain-Control Interface, ARMA Model Introduction to ***Brain Control Interface*** Fundamentals of BCI – Structure of BCI system – Classification of BCI: Invasive, Non-invasive and Partially invasive BCI Brain signal acquisition, Experiment design and data analysis (with explanation of one-way ANOVA), ARMA Model

Humanoids & HMI/BMI Applications: Hierarchical Task] Analysis, Dialog Design, Use of FSM] Task modelling and analysis through Hierarchical task analysis (HTA), GUI design for a mobile phone based Matrimonial application, Employment Information System for unorganized construction workers on a Mobile Phone. Dialog Design using FSM (finite state machines), Cognitive architecture, Object Oriented Modelling of User Interface Design

Text Books:

1. Dix A., Finlay J., Abowd G. D. and Beale R. Human Computer Interaction, 3rd edition, Pearson Education, 2005.
2. Preece J., Rogers Y., Sharp H., Baniyon D., Holland S. and Carey T. Human Computer Interaction, Addison-Wesley, 1994.

Reference Books:

1. B. Schneiderman; Designing the User Interface, Indian Reprint, Addison Wesley 2000.
2 Jonathan Wolpaw,Elizabeth Winter Wolpaw,'Brain Computer Interfaces: Principles and practice", Edition 1, Oxford University Press, USA, January 2012

Web References

1 https://www.expertsnotes.com/2016/04/jntuk-r-10-4-2-cse-human-computer.html
2 https://nptel.ac.in/courses/106103115/4
3 http://www.eolss.net/sample-chapters/c18/e6-43-37-06.pdf
4 https://www.Tutorials.in/How_Does_Your_HMI_Design.
5 Special Issue on Brain Control Interfaces, IEEE Transactions on Neural Systems and Rehabilitation Engineering, Vol 14, June 2006

21EC3074-COMPUTER VISION & APPLICATIONS

L-T-P-S : 3-0-0-0
Credits : 3
ContactHours : 3
Pre-requisite :NIL

Mapping of Course Outcomes to Program outcomes:

CO#	Course Outcome	PO/PSO	BTL
CO1	Understanding of the fundamental concepts related to multi-dimensional signal processing.	**1**	**2**
CO2	Understanding of the feature extraction, pattern analysis visual geometric modelling, stochastic optimization.	**1**	**2**
CO3	Knowledge of these concepts is necessary in this field, to explore and contribute to research and further developments in the field of computer vision.	**1,2**	**2**
CO4	Applications range from Biometrics, Medical diagnosis, document processing, mining of visual content, to surveillance, advanced rendering.	**5**	**2**

Syllabus:

Introduction to Computer Vision (CV)

Basic Block Diagram Computer Vision; Principle of Computer Vision; Perception of 2 Dimensional & 3Dimensional Transformation (2DCVT &3DCT); 3D Rotation; Histogram, Texture Analysis;, Image formation, Geometric Primitives and transformations, Geometric Primitives, 3D to 2D Projections, Lens distortions, Color, Compositing and matting, Point, Pixel transforms, Histogram equalization, Application: Tonal adjustment, 4D to 11D Transformation on CV.

Optical Features Extraction (OFE)

Overview of Feature Extraction on Computer Vision ; Edges, HOG, SIFT, SURF, DTW, Gabor Filter, Scale Space Analysis; Analysis Edges, Edge detection , Edge linking , Application: Edge editing and enhancement ,A comparative study of CFs, LBP, HOG, SIFT, SURF, and BRIEF for security and face recognition , Gabor filter for image processing and computer vision.

Video Features & CV Methods

Optical Flow, Optical Flowrate, Elastic Band, Boundary Detection.

Optical Flow-Rate ,Optical Flow Estimation,Ealstic Band ,Selection of Terminal Point of the Line, Texture Segmentation, Edge Flow and Anisotropic Diffusion, Edge Flow Definition ,Edge Flow Intensity ,Edge Flow Texture, Edge Flow , Edge Flow Based on Gabor Phase , Edge Flow Integration , Edge Flow Propagation and Boundary Detection.

Pattern Analysis-Dimension Reduction

VQ, ICA, KNN, PCA, LDA, Classifiers: GMM, SVM, CNN, DNN Gaussian Mixture Model and Deep Neural Network Recognizing faces with PCA and ICA, K-nearest Neighbors (KNN) ,Classification ModelLDA in Python for Computer Vision **,**LDA in Python for Computer Vision, Deep Learning for Computer Vision, Support Vector Machines (SVM), Image Processing with the Computer Vision APIvision field, LDA in Python for Computer Vision, Robust Principal Component Analysis for Computer Vision, Diagnosis and Treatment of Computer Vision Syndrome, Image Classifier using CNN.

Text Books

1 Ayman Al Falou -Advanced Secure Optical Image Processing for Communications APRIL 2008
2 Richard Szeliski- Computer Vision: Algorithms and Applications March 30, 2008

References

3 Noah Snavely's - Introduction to Computer Vision class at Cornell Tech (Spring 2019)
4 Bharath Hariharan's - Computer Vision class at Cornell (Spring 2019)
5 Pascal Fua's - Introduction to Computer Vision class at EPFL (Spring 2019)
6 IoannisGkioulekas's - Computer Vision class at CMU (Spring 2019)
7 IoannisGkioulekas's - Computational Photography class at CMU (Fall 2018)

Web References:

1. https://www.javatpoint.com/computer-graphics-elastic-or-rubber-band-techniques
2. http://www.cs.jhu.edu/~misha/ReadingSeminar/Papers/Ma00.pdf
3. **https://www.geeksforgeeks.org/image-classifier-using-cnn/**
4. http://vqlsr.com/vision-services/computer-vision.html

21EC3072-AUTONOMOUS VEHICLES & AUTOMOTIVE ELECTRONICS

L-T-P-S: 3-0-0-0

Credits : 3

Pre-requisites : NIL

Mapping of Course Outcomes to Program outcomes:

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand the basics of Autonomous Vehicles, dynamics and design electronics to complement those features.	1,2	2
CO2	To understand sensors and sensor monitoring mechanisms aligned to automotive systems, different signal conditioning techniques, interfacing techniques and actuator mechanisms. To understand role of Microcontrollers in ECU design and choice of appropriate Hardware and Software	2,3	3
CO3	Describe the function of basic components used in modern automotive systems To provide an overview of the Automotive Open Systems Architecture (AUTOSAR)	2,3	3
CO4	Design and implement Illustrate the practical applications of Automotive Open Systems Architecture (AUTOSAR)	2,3	3

Syllabus:

Introduction to Autonomous Vehicles

Technological overview concepts of Autonomous Vehicles (AVs); History of Autonomous Vehicles; Vehicle Electronics Architecture; Vehicle Operating Software; Functional Block Diagram of typical Autonomous Vehicle System (AVS); Society of Automotive Engineers Levels of Automation; Major Functions of physical Ecosystem of an Autonomous Vehicle (cameras, radar, lidar, gps, ultrasonic sensors, central computer, DRSC-based Receiver); Autonomous Vehicle architecture (JAUS & GOA);

Driver Assisted/Driverless Vehicles, Connected Vehicles:

Basic control system applied to Drive Assisted, Driverless, Connected Vehicles; Overview of the operation of Electronic Control Unit (ECUs); Basic cyber-physical system theory and autonomous vehicles; Comparison chart of deriver assisted vs driverless vehicle and connected Vehicles vs Autonomous Vehicles.

Sensor Technology for Autonomous Vehicles

Basics of Radar Technology and Systems -Ultrasonic Sonar Systems -LIDAR Sensor Technology andSystems-camera technology -night vision technology -Use of Sensor Data Fusion -Kalman Filters Computer Vision and Deep Learning for Autonomous Vehicles Computer Vision Fundamentals -Advanced Computer Vision -Neural Networks for Image Processing –TensorFlow-overview of Deep Neural Networks -Convolutional Neural Networks-DSRC (Direct Short-Range Communication) -Vehicle-to-Vehicle Technology-Vehicle-to-Roadside and Vehicle-to-InfrastructureLocalization - Path

Planning-Controllers toActuate a Vehicle - PID Controllers -Model Predictive Controllers, ROS Framework-Technical Issues, Security Issues, Moral and Legal Issues

Automotive Electronics (AE)

Introduction to Modern Automotive Systems-Evolution of Electronics and Software in automobiles -ECUs and their application areas in Automotive -Engine Management Systems -Body & Comfort Electronics Systems -Infotainment Systems -Advanced Driver Assistance Systems and V2X Systems -Autonomous Driving Systems -Current Trends and Challenges

Micro Controllers in ECU Design:Overview of AURIX Micro Controller -Architecture, Memory Map, Lock Step etc. -Peripherals used inAutomotive Applications -GTM, QSPI, DSADC etc. -AURIX SafeTLib -Real time Operating Systems and Scheduling Concepts -Practical Experiments using AURIX Eval Kit

Bluetooth low energy and the automotive(BLE-AE):Block Diagram-Functional of personalization using BLE-AE, Piloted/assisted/remote parking BLE-AE.

Automotive Wireless (AW) :Wireless Networking and Applications to Vehicle Autonomy; Integration of Wireless Networking and On-Board Vehicle Networks; Wireless Access in Vehicular Environments (WAVE) amendment to IEEE 802.11; IEEE 802.11ac WLAN PHY and dual-band (2.4 GHz/5 GHz) support ; EEE 1609 - Family of Standards for Wireless Access in Vehicular Environments (WAVE).Automotive GPRS Vehicle Tracking (AGPRS-VT) Vehicle Tracking System; Principle of working for Vehicle Tracking system. GPS and GPRS tracking system

Embedded to Automotive Electronics and autonomous Vehicles:

Invehicle communication protocols: Overview of In-Vehicle Communication Protocols – CAN, LIN, Flex Ray, MOST, Ethernet -Controller AreaNetwork (CAN)-CANoe, CANalyzer Fundamentals -CAPL Scripting, Panel Simulation.

Vehicle Area Network (VAN):Architecture-EBD-ESP-ICP-OPC-RPVs- UAVVehicle Networking & Diagnostics Stacks– KWP 2000 and UDS.

Automotive Functional Testing: HIL, MIL and SIL testing-AUTOSAR Overview -RTE, BSW, SWC-Practical Experiments using AUTOSAR Tools-Automotive Quality, Safety and Security Standards Common Failures in Automotive Systems -ASPICE Development Process -MISRA C Standard -ISO 26262-Functional Safety Standard -SAE J3061 Security Standard. Case studies on design Project Automotive Sensors, Drives, Actuators

Text Books

[1]. Ronald K Jurgen: “Distributed Automotive Embedded Systems” SAE International, 2007
[2]. Williams. B. Ribbens: “Understanding Automotive Electronics”, 7th Edition, Elsevier Inc, 2012.
[3]. Crating Autonomous Vehicle Systems by shaoshanliu, liyun li
[4]. Autonomous vehicles: opportunities, Strategies, and Disruptions by Michael McGrath

Reference Books

[5]. Automotive Embedded Systems Handbook CRC Press Taylor & Francis Group Richard Zurawski

[6]. Bosch Automotive Electrics and Automotive Electronics Systems and Components, Networking and Hybrid Drive Robert Bosch GmbH (Ed.) 5th Edition

[7]. William B Ribbens "Understanding Automotive Electronics", SAE Publications, 1998
Robert Bosch, "Gasoline Engine Management" SAE Publications, 2006.

[8]. Marc E. Herniter and Zac Chambers: “Introduction to Model Based System Design”, RoseHulman Institute of Technology. Rudolf Limpert, “Brake design and Safety”. SAE Publications, 2015,

MOOCS/Web Links

1. https://www.automotive-iq.com/events-autonomous-vehicles-online
2. https://swayam.gov.in/nc_details/NPTEL

https://www.themanufacturer.com/articles/will-autonomous-vehicles-drive-improvement-in-electronic-reliability/

22EE3241-POWER TRAIN DESIGN FOR ELECTRIC VEHICLE

L-T-P-S: 2-1-0-0
Credits: 3 **Pre-Requisite: Nil**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand the History, Economics, Environmental issues and power train of Electric Vehicles	-	2
CO2	Analyze the dynamics of EV	PO2/ PSO1	4
CO3	Select and size the power train for 2W	PO1/ PSO1	3
CO4	Select and size the power train for 4W	PO1/ PSO1	3

Syllabus:

HISTORY, ECONOMIC & ENVIRONMENTAL IMPACT OF ELECTRIC VEHICLE

History of EV, Case studies on Economic and Environment aspects of EV, EV markets – Supply and demand, Economical analysis with case study, Environmental impact analysis with case study. Impact of different transportation technologies on environment and energy supply.

Power train components: BEV, HEV, PHEV and FCEV including working of Fuel cell, **Super capacitor, energy management, Hybrid sources.**

INTRODUCTION TO EV DYNAMICS

Motion and dynamic equations of electric vehicles, General description of vehicle movement, Vehicle resistance, Dynamic equation, Tire Ground Adhesion and maximum tractive effort, different drive cycles for, Drive cycles for vehicle emission, fuel consumption and performance testing.

2W POWER TRAIN SIZING

Chassis, differential and transmission selection for different drive trains, Battery, converter and motor drive sizing for different 2W drive trains. Analysis on the effect of sizing of different components for different drive cycles

4W POWER TRAIN SIZING

Chassis, differential and transmission selection for different drive trains, Battery, converter and motor drive sizing for different 4W drive trains. Analysis on the effect of sizing of different components for different drive cycles

Text books:

1. "A History of Electric Vehicles" by Nigel Burton, Edition -1, Crowood Publisher.
2. "Electric Cars: The Ultimate Guide for Understanding the Electric Car And What You Need to Know" by Brad Durant

Reference books:

1. "Electric Vehicle Technology Explained" by James Larminie and John Lowry.

22ME4091-SOLAR ENERGY TECHNOLOGIES

L-T-P-S : 2-0-2-0

Credits: 3

Pre Requisite: Nil

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand the basics of solar radiation and working principle of various solar collectors	PO2	2
CO2	Understand the working of solar thermal systems	PO2	2
CO3	Understand the fundamentals of Solar PV technology	PO2	2
CO4	Apply the knowledge of thermodynamics and heat transfer to calculate the performance of solar PV systems	PO2	3
CO5	Analyze various solar thermal and PV systems using TRNSYS software	PO5	4

Syllabus:

Solar Radiation and collectors: Solar angles – Sun path diagrams – Radiation - extraterrestrial characteristics - measurement and estimation on horizontal and tilted surfaces - flat plate collector thermal analysis - testing methods- evacuated tubular collectors - concentrator collectors – classification - design and performance parameters- tracking systems - compound parabolic concentrators - parabolic trough concentrators - concentrators with point focus - Heliostats – performance of the collectors

Solar Thermal Systems: Principle of working, types, design and operation of - Solar heating and cooling systems – Thermal Energy storage systems – Solar Desalination – Solar cooker : domestic, community – Solar pond – Solar drying

Solar PV fundamentals – Semiconductor – properties - energy levels - basic equations of semiconductor devices physics. Solar cells - p-n junction: homo and hetero junctions - metal-semiconductor interface - dark and illumination characteristics - figure of merits of solar cell - efficiency limits - variation of efficiency with band-gap and temperature - efficiency measurements - high efficiency cells – Solar thermo-photovoltaics.

Analysis of Solar PV Systems: Solar cell array system analysis and performance prediction-Shadow analysis: reliability - solar cell array design concepts - PV system design - design process and optimization - detailed array design - storage autonomy - voltage regulation - maximum tracking - centralized and decentralized SPVsystems - stand alone - hybrid and grid connected system - System installation - operation and maintenances - field experience - PV market analysis and economics of SPV systems

Experiments:

- Analysis of flat plate and parabolic trough arrays
- Simulation and analysis of solar radiation over flat plate solar collector
- Simulation and analysis of solar radiation over parabolic solar collector

- Analysis of solar water heater
- Analysis of CPC collector
- Analysis of Evacuated Tube collector
- Performance estimation of direct solar still
- Performance estimation of indirect solar still
- Integration of PV cell and battery
- Analysis of sensible heat storage device

Recommended Books

6. Goswami, D.Y., Kreider, J. F. and & Francis., Principles of Solar Engineering, Taylor and Francis,2000
7. Chetan Singh Solanki, Solar Photovoltatics – Fundamentals, Technologies and Applications, PHILearning Private limited, 2011
8. Sukhatme S P, J K Nayak, Solar Energy – Principle of Thermal Storage and collection, TataMcGrawHill, 2008.
9. Solar Energy International, Photovoltaic – Design and Installation Manual – New SocietyPublishers, 2006
10. Roger Messenger and Jerry Vnetre, Photovoltaic Systems Engineering, CRC Press, 2010.

22ME4092-VEHICLE DYNAMICS

L-T-P-S: 3-0-0-0

Credits: 3

Pre-Requisite:Nil

CO No.	CO Statement	PO/PSO mapping	BTL
1	Analyse the dynamics of Steering system on vehicle performance	PO2-2	4
2	Analyse Dynamics of vehicle suspension systems	PO2-2`	4
3	Analyse Dynamics of vehicle body vibrations	PO2-2	4
4	Analyse the 2D stability of automobile vehicles	PO2-1	4

Syllabus:

Syllabus Contents: Tyres: Necessity of rubber tyres in road vehicles. Functions of tyres. Tyre adhesion. Tyre construction. Cross-ply and radial-ply tyres. Tubed and tubeless tyres. Tyre elasticity. Cornering power. Self aligning torque.

Steering and Wheel Alignment: Steering geometry. Ackermannmechanism and Davis mechanism. Steering gears. Power steering. Camber, castor, kingpin inclination and toe-in, toe-out. Scrub radius. Moments on steering wheels.

Suspension system: Functions of suspension system. Rigid axle and independent suspension system. Hotchkiss drive, torque-tube drive and radius rods. Types of suspension springs and their characteristics. Design of leaf spring and coil spring. Anti-roll bar. Wheel balancing. Oscillations of steerable wheels. Shock absorber.

Body vibrations: Bouncing and pitching. Doubly conjugate points. Body rolling. Roll center and roll axis. Stability against body rolling.

Handling Characteristics: Over steer and under steer. Vehicle stability while braking. Dynamic axle loads. Anti-squat, anti-pitch and anti-dive suspension geometry.

2-D Stability of Automobile Vehicles: Steady state response to steering input, side force input and yawing moment input. Transient responses

References:

1. J.R.Ellis . Vehicle dynamics.
2. P.M. Heldt Automative Chassis
3. W. “steeds. Mechanics of road vehicles
4. J. G. Giles steering ,suspensions, tires
5. T. D. Gillespie. Fundamentals of Vehicle dynamics.

22ME4077-THERMAL MANAGEMENT OF ELECTRIC AND ELECTRONIC SYSTEMS

L-T-P-S:3-0-0-0

CREDITS:3

Pre Requisite: Nil

CO#	Course Outcome	PO/PSO	BTL
CO1	Apply the concepts of heat transfer to various electric and electronic systems requiring heat dissipation	PO1-2	3
CO2	Apply different cooling techniques to microchannels, heat pipes and vapor chambers	PO1-2	3
CO3	Apply various thermal management techniques in the fields of automobiles and electronics	PO1-2	3
CO4	Analyze the Battery thermal management system and battery pack design	PO2-1	4

Syllabus:

Introduction to Thermal Management in Electronics -heat transfer modes, electronics packaging, contact and spreading resistances, heat sink design, thermal interface material(TIM)

Cooling Technologies-thermal interface and phase change materials, active, passive and novel air cooling approaches, microchannels, jet impingement, immersion cooling, heat pipes and vapor chambers, thermoelectric

Applications of thermal management: avionics, data centers, mobile, internet of things, high-performance computing, automotive, etc

Lithium-ion battery configuration and operation, Sources of heat in Lithium-ion battery, Lithium Ion-cell temperature ranges. Battery Thermal Management System (BTMS): Need of BTMS, Technologies of BTMS, Battery pack design.

.

TEXT BOOKS:

T.L. Bergman, A.S. Lavine, F.P. Incropera, D.P. DeWitt, Fundamentals of Heat and Mass Transfer, Wiley, 2011)

22EE4141-AI & IOT FOR ELECTRIC VEHICLE

L-T-P-S: 2-0-2-0
Credits: 3
Pre-Requisite: Nil
Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Demonstrate IoT devices and tools	PO2	2
CO2	Operate the cloud system Environment	PO4	3
CO3	Utilize AI and ML Techniques	PO2	3
CO4	Utilize AI techniques for EV Applications	PO7	3
CO5		PO4, PO5	

Syllabus:
IoT Devices and Enabling Technologies: Sensor Devices- temperature, vibration, irradiance, wind speed, PIR, proximity, current, voltage Controllers, Actuators, Networking and Communication Protocols, Data analytics using AI and ML for – smart cities, smart grid, smart building, electrical vehicles Cloud Computing: Basics-Cloud systems, Cloud computing protocols, Role of Web services, Deployment Models- Public, Community, Hybrid, Private Clouds, Cloud Analytics over Thingspeak, Google Firebase, AWS-console, Functions. Database Services-Relational DBMS, RDS Services. AI and ML on Cloud: Data Pre-processing techniques in Machine Learning, Data-handling, importing libraries, Data pre-processing using python, Missing data, Categorical Data. Regression and Classification algorithms in ML. Cloud based Real- time Monitoring systems, M2M communications, Case Studies Applications: Electric Vehicle Battery state estimation, health monitoring, SOL determination, Power management, Charging optimization and Electric Drive applications, Online vehicle Assistance

Text books:
1. Artificial Intelligent Techniques for Electric and Hybrid Electric Vehicles, Chitra A., P. Sanjeevikumar, Jens Bo Holm-Nielsen and S. Himavathi
2. Internet of Things An Application Based approach Using Arduino Platform and Firebase by SOURAV KUMAR BHOI, Independently published (May 31, 2018)
3. Hybrid Electric Vehicles-Principles and Applications with practical perspectives, Chris Mi, M. Abdul Masrur and David Wenzhong Gao, Wiley Publications,1 edition 2011
4. AWS Certified Machine Learning Specialty: MLS-C01 Certification Guide By Somanath Nanda, Weslley Moura · 2021

Reference Books:
1. Electric and Hybrid Vehicles power sources, models, sustainability, infrastructure and the market, Edited by Gianfranco Pistoia, Elsevier 1 edition 2010.
2. Electric and Hybrid Vehicles Design Fundamentals, by Iqbal Hussain, CRC Press2nd edition, 2010. 7. Role of Single Board Computers (SBCs) in Rapid IoT Prototyping, By G. R. Kanagachidambaresan · 2021

22EE4142-COMMUNICATION PROTOCOLS & TESTING OF ELECTRIC VEHICLE

L-T-P-S: 2-0-2-0
Credits: 3
Pre-Requisite: Nil
Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Analyse the protocols used for Electric Vehicle communica	PO1, PO5	2
CO2	Apply the communication protocols for fault diagnostics of Electric Vehicle	PO1, PO3	3
CO3	Analyze the intricacies of integrating HV and LV components of vehicle	PO1, PO6	4
CO4	Understand the overview of system engineering/system validation	PO1, PO3	2
CO5	Test electric vehicle fault		

Syllabus:
Introduction to serial communication protocols: SPI I2C CAN, CAN standard, CAN message: Arbitration, message types, valid frame, error checking CANbus: Transceiver features, CAN physical layer, CAN connectors, Bit Timing, Error Handling, High Layer Protocols: IEC 61851, SAE J2601, Vehicle to Vehicle communication protocols Common Sensors modules used in EV: Air Bag, ABS, Window Mirror, Cruise Control, Transmission control, CAN Interface with Sensor Modules Power Distribution Box, Components like HVDC Relays connections, Insulation Monitoring Devices Fuses, BTMS, Driveline Cooling, Coolant tanks, Level Sensors, Vehicle Wiring, Terminals, Electrical Distribution Boards, Temperature Considerations for wiring, Cable selection, Instrument Panel, HVIL,24V converters, Junction boxes or Fuse Boxes, Fuses, derating, EMI and EMC. V cycle, reliability calculations, DFMEA/FMEA analysis, Design for manufacturing, servicing & data analytics, supply chain management

Text books:
1.“A History of Electric Vehicles” by Nigel Burton, Edition -1, Crowood Publisher.
2.“Electric Cars: The Ultimate Guide for Understanding the Electric Car And What You Need to Know” by Brad Durant

Reference Books:
1.“Electric Vehicle Technology Explained” by James Larminie and John Lowry

22ME4094-Autonomous Vehicles & Automotive Electronics

L-T-P-S: 3-0-0-0
Pre-requisites : NIL
Credits: 3

Mapping of Course Outcomes to Program outcomes:

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand the basics of Autonomous Vehicles, dynamics and design electronics to complement those features.	1,2	2
CO2	To understand sensors and sensor monitoring mechanisms aligned to automotive systems, different signal conditioning techniques, interfacing techniques and actuator mechanisms. To understand role of Microcontrollers in ECU design and choice of appropriate Hardware and Software	2,3	3
CO3	Describe the function of basic components used in modern automotive systems To provide an overview of the Automotive Open Systems Architecture (AUTOSAR)	2,3	3
CO4	Design and implement Illustrate the practical applications of Automotive Open Systems Architecture (AUTOSAR)	2,3	3

Syllabus:

Introduction to Autonomous Vehicles

Technological overview concepts of Autonomous Vehicles (AVs); History of Autonomous Vehicles; Vehicle Electronics Architecture; Vehicle Operating Software; Functional Block Diagram of typical Autonomous Vehicle System (AVS); Society of Automotive Engineers Levels of Automation; Major Functions of physical Ecosystem of an Autonomous Vehicle (cameras, radar, lidar, gps, ultrasonic sensors, central computer, DRSC-based Receiver); Autonomous Vehicle architecture (JAUS & GOA);

Driver Assisted/Driverless Vehicles, Connected Vehicles:

Basic control system applied to Drive Assisted, Driverless, Connected Vehicles; Overview of the operation of Electronic Control Unit (ECUs); Basic cyber-physical system theory and autonomous vehicles; Comparison chart of deriver assisted vs driverless vehicle and connected Vehicles vs Autonomous Vehicles

Sensor Technology for Autonomous Vehicles

Basics of Radar Technology and Systems -Ultrasonic Sonar Systems -LIDAR Sensor Technology andSystems-camera technology -night vision technology -Use of Sensor Data Fusion -Kalman Filters Computer Vision and Deep Learning for Autonomous Vehicles Computer Vision Fundamentals - Advanced Computer Vision -Neural Networks for Image Processing –TensorFlow-overview of Deep Neural Networks -Convolutional Neural Networks-DSRC (Direct Short-Range Communication) - Vehicle-to-Vehicle Technology-Vehicle-to-Roadside and Vehicle-to-InfrastructureLocalization - Path Planning-Controllers toActuate a Vehicle - PID Controllers -Model Predictive Controllers, ROS Framework-Technical Issues, Security Issues, Moral and Legal Issues

Automotive Electronics (AE)

Introduction to Modern Automotive Systems-Evolution of Electronics and Software in automobiles - ECUs and their application areas in Automotive -Engine Management Systems -Body & Comfort Electronics Systems -Infotainment Systems -Advanced Driver Assistance Systems and V2X Systems -Autonomous Driving Systems -Current Trends and Challenges

Micro Controllers in ECU Design:Overview of AURIX Micro Controller -Architecture, Memory Map, Lock Step etc. -Peripherals used inAutomotive Applications -GTM, QSPI, DSADC etc. -AURIX SafeTLib -Real time Operating Systems and Scheduling Concepts -Practical Experiments using AURIX Eval Kit

Bluetooth low energy and the automotive(BLE-AE):Block Diagram-Functional of personalization using BLE-AE, Piloted/assisted/remote parking BLE-AE.

Automotive Wireless (AW) :Wireless Networking and Applications to Vehicle Autonomy; Integration of Wireless Networking and On-Board Vehicle Networks; Wireless Access in Vehicular Environments (WAVE) amendment to IEEE 802.11; IEEE 802.11ac WLAN PHY and dual-band (2.4 GHz/5 GHz) support ; EEE 1609 - Family of Standards for Wireless Access in Vehicular Environments (WAVE).Automotive GPRS Vehicle Tracking (AGPRS-VT) Vehicle Tracking System; Principle of working for Vehicle Tracking system. GPS and GPRS tracking system

Embedded to Automotive Electronics and autonomous Vehicles:

Invehicle communication protocols: Overview of In-Vehicle Communication Protocols – CAN, LIN, Flex Ray, MOST, Ethernet -Controller AreaNetwork (CAN)-CANoe, CANalyzer Fundamentals -CAPL Scripting, Panel Simulation.

Vehicle Area Network (VAN):Architecture-EBD-ESP-ICP-OPC-RPVs- UAVVehicle Networking & Diagnostics Stacks– KWP 2000 and UDS.

Automotive Functional Testing: HIL, MIL and SIL testing-AUTOSAR Overview -RTE, BSW, SWC-Practical Experiments using AUTOSAR Tools-Automotive Quality, Safety and Security Standards Common Failures in Automotive Systems -ASPICE Development Process -MISRA C Standard -ISO 26262-Functional Safety Standard -SAE J3061 Security Standard. Case studies on design Project Automotive Sensors, Drives, Actuators

Text Books

1. Ronald K Jurgen: “Distributed Automotive Embedded Systems” SAE International, 2007
2. Williams. B. Ribbens: “Understanding Automotive Electronics”, 7th Edition, Elsevier Inc, 2012.
3. Crating Autonomous Vehicle Systems by shaoshanliu, liyun li
4. Autonomous vehicles: opportunities, Strategies, and Disruptions by Michael McGrath

Reference Books

5. Automotive Embedded Systems Handbook CRC Press Taylor & Francis Group Richard Zurawski
6. Bosch Automotive Electrics and Automotive Electronics Systems and Components, Networking and Hybrid Drive Robert Bosch GmbH (Ed.) 5th Edition
7. William B Ribbens "Understanding Automotive Electronics", SAE Publications, 1998 Robert Bosch, "Gasoline Engine Management" SAE Publications, 2006.
8. Marc E. Herniter and Zac Chambers: “Introduction to Model Based System Design”, RoseHulman Institute of Technology. Rudolf Limpert, “Brake design and Safety”. SAE Publications, 2015,

MOOCS/Web Links

1. https://www.automotive-iq.com/events-autonomous-vehicles-online
2. https://swayam.gov.in/nc_details/NPTEL

https://www.themanufacturer.com/articles/will-autonomous-vehicles-drive-improvement-in-electronic-reliability/

OPEN ELECTIVES

22ME40B4 – ROBOTICS

L-T-P-S : 3-0-0-0
Credits : 3
Contact Hours : 3
Pre-requisites : NIL

Mapping of Course Outcomes with PO/PSO:

CO#	Course outcome	PO/PSO	BTL
CO1	Analyze the anatomy of existing robotic systems and their performance specifications, end effectors etc	PO3, PO5	4
CO2	Analyze a robotic system with respect to the suitable sensors, actuators for its performance.	PO3	4
CO3	Understand manipulator kinematic analysis and joint trajectory plan for a given end effector.	PO3	2
CO4	Classification of Robot Languages, Comprehensive identification of suitable Robotic system for various applications.	PO5	4

Syllabus:

Introduction to Robotics, Major components of a Robot, Robotic like devices, Classification of Robots – Classification by coordinate system and by control method, Specifications of Robots, Fixed versus flexible automation, economic analysis.

ROBOT END EFFECTORS: Introduction, End effectors, interfacing, types of End effectors, grippers and tools, considerations in the selection and design of remote cantered devices.

ROBOTIC SENSORY DEVICES: Objective, Non-Optical position sensors – Potentiometers, Synchros, inductosyn, optical position sensors – opto interrupters, Optical encoders (absolute & incremental).

PROXIMITY SENSORS: Contact type, non-contact type – reflected light scanning laser sensors.

TOUCH & SLIP SENSORS: Touch sensors – proximity Rod & Photo detector sensors, Slip sensors– Forced oscillation slip sensor, interrupted type slip sensors, force and torque sensors.

TRANSFORMATIONS AND KINEMATICS: Objectives, homogeneous coordinates, basic transformation operations, forward solution – Denavit Hartenberg procedure, Simple problems involving planar manipulators, inverse or backward solution – problems involved, techniques.
Introduction to Trajectory Planning, the manipulator jacobian.

ROBOT APPLICATIONS: Industrial Applications – Material Transfer, material handling, Loading and unloading, processing, spot and continuous arc welding, spray painting, grinding, Assembly and Inspection and Non-Industrial Applications.

ROBOT LANGUAGES: Introduction, AL, AML, VAL, RAIL

Text Books:

1. Robotic engineering by Richard D. Klafter, Prentice Hall India
2. Industrial robotics by Mikell P.Groover, Mcgraw Hill Publications

Reference Books:

1. Robotics – K.S. Fu, Gonzalez & Lee, Mcgraw Hill Publications
2. Robotics for Engineers by Yoram koren, Mcgraw Hill Publications
3. Introduction to Robot Technology, - P.Coiffet and M.Chairenze / Kogam Page Ltd. 1983 London.

22ME40B5 – MECHATRONICS

L-T-P-S : 3-0-0-0
Credits : 3
Contact Hours : 3
Pre-requisites : NIL

Mapping of Course Outcomes with PO/PSO:

CO#	Course outcome	PO/PSO	BTL
CO1	Identify appropriate sensor, Identify appropriate actuation system for a given application.	PO2	3
CO2	Identify appropriate microcontroller for a given application and to build a mathematical Model of system for evaluating open loop system performance and behaviour.	PO2	3
CO3	Identify an appropriate closed loop control strategy to attain the desired system behaviour.	PO2	3
CO4	Suggest a Mechatronic product design for a given application and evaluate its performance.	PO3	3

Syllabus:

INTRODUCTION TO MECHATRONICS: Introduction, Elements of Mechatronic system, Applications. SENSORS AND TRASDUCERS: Introduction, Classification of Sensors, selection of sensors. Classification of transducers - strain gauges, displacement transducers, capacitive and inductive transducers, LVDT, oscillation transducer, piezoelectric, potentiometric, velocity transducers, temperature transducers, optical transducers.

SIGNAL CONDITIONING: Introduction, data acquisition –Quantizing theory, Analog to Digital conversion, Digital to Analog conversion.

DATA PRESENTATION SYSTEMS: Data presentation elements, Data acquisition systems, systems measurement, Testing and calibration.

ACTUATION SYSTEMS: Pneumatic and hydraulic actuation systems, Stepper and Servo Motor.

SYSTEM MODELS: Modelling of one and two degrees of freedom Mechanical, Electrical, fluid and thermal systems. Block diagram representations for these systems.

SYSTEM RESPONSE: Introduction, Transfer function, Time response and Frequency response analysis mechanical systems and electrical systems.

CLOSED LOOP CONTROLERS: Continuous and discrete processes, control modes, Two-step, proportional, Derivative, integral, PID controllers.

DIGITAL LOGIC: Logic gates, Boolean algebra, Karnaugh maps. PLC: Introduction, basic structure, I/P ,O/P processing, programming, ladder diagrams, Timers, Internal relays and counters ,data handling, Analogue Input and Output, selection of a PLC.

DESIGN: Mechatronics system Design, possible design solutions.

CASE STUDY: pick and place Robot, CNC Machine.

Text books:

1. Bolton, ‖Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering‖, 3rd Edition, Pearson education, 2007.
2. David G. Alciatore, Michael B. HI stand, ‖ Introduction to mechatronics and measurement systems‖, 2nd Edition, McGraw-Hill Professional, 2002.

Reference books:

1. A.K.Sawhney, "A course in Electrical and Electronic Measurement and Instrumentation"- Dhanpat Rai & Sons - 1991.
2. Nitaigour Premchand Mahalik, ―Mechatronics‖, Tata McGraw-Hill, 2003.

22ME40B6 – OPERATIONS RESEARCH

L-T-P-S : 3-0-0-0
Credits : 3
Contact Hours : 3
Pre-requisites : NIL

Mapping of Course Outcomes with PO/PSO:

CO#	Course outcome	PO/PSO	BTL
CO1	Model and Solve for the optimum solutions using LPP	PO5	3
CO2	Model and Find the Optimized solutions for the problems in the field of Transportation and Management / Assignments.	PO5	3
CO3	Model and Optimize Game theory, Dynamic Part Programming, Queuing Theory , Inventory Control & Simulation Problems	PO5	3
CO4	Understand and solve the Concepts related to PERT/CPM	PO5	3

Syllabus:

Introduction to Operations Research: Introduction, Modeling in Operations Research, Phases of OR study, Scope and application of OR. Linear Programming and its Applications: Linear Programming Problem – Graphical solution of LP Problem. Simplex method, Big M method, two phase method, multiple solution, infeasible solution, unbounded solution, degeneracy, Dual Simplex method.

Transportation: Introduction – Methods of basic feasible solution, Optimality test, Degeneracy in transportation problem, unbalanced transportation Problem, Assignment Problems: Hungarian method for assignment problem, Traveling salesman problem.

Theory of Games: Introduction, to solve the rectangular two-person zero sum games, solution of rectangular games in terms of mixed strategies, solution of 2x2 games without saddle point, solution of a two person zero sum 2Xn game, Graphical method for 2Xn and nX2 games.

Inventory Control: Introduction – EOQ with uniform rate of demand, Economic lot size with finite rate of replenishment, Quantity discounts, Deterministic model with Shortages, ABC analysis of inventory.

Dynamic Programming: Introduction, Bellman's principle of optimality, application to shortest route problem, linear programming, tabular method.

Queuing Theory: Introduction, single channel, Poisson arrival, exponential service time with finite population and infinite population, Simulation: Introduction, Monte Carlo Simulation, And Application to Inventory Control.

Project Management by PERT/CPM: Introduction, simple network techniques, construction rules of drawing, Fulkerson's rule, Critical path method (CPM)- floats, critical path, project duration, PERT: Introduction, different Time estimates, expected time, variance, expected project duration and probability of completion. Crashing: Introduction, crashing of network, problem

Text books:

1. Operations Research - Hamdy Taha
2. Operations Research – Hiller & Liberman.

Reference Books:

1. Operations Research – A.M. Natarajan
2. Operations Research – S.D. Sarma

22ME40B7 – HYBRID ELECTRIC VEHICLES

L-T-P-S : 3-0-0-0
Credits : 3
Contact Hours : 3
Pre-requisites : NIL

Mapping of Course Outcomes with PO/PSO:

CO#	Course outcome	PO/PSO	BTL
CO1	Understand the functioning of electric vehicle components and comparison with Internal combustion	PO1	2
CO2	Determine the Motor Torque Calculations for Electric Vehicle	PO4	3
CO3	Understand the classification of Electric vehicles and working of various fuel cells	PO1	2
CO4	Understand the importance and working of motors in Electric drive.	PO4	2

Syllabus:

Introduction: Electric Vehicle History, Components of Electric Vehicle, Comparison with Internal combustion, Engine: Technology, Comparison with Internal combustion Engine: Benefits and Challenges, EV classification and their electrification levels, EV Terminology

Motor Torque Calculations for Electric Vehicle: Calculating the Rolling Resistance, calculating the grade resistance, Calculating the Acceleration Force, Finding The Total Tractive Effort, Torque Required On The Drive Wheel.

Electric Vehicle Architecture Design: Types of Electric Vehicle and components, Electrical protection and system requirement, Photovoltaic solar based EV design, Battery Electric vehicle (BEV), Hybrid electric vehicle (HEV), Plug-in hybrid vehicle (PHEV), Fuel cell electric vehicle (FCEV), Electrification Level of EV, Comparison of fuel vs Electric and solar power, Solar Power operated Electric vehicles.

Electric Drive and controller: Types of Motors, Selection and sizing of Motor, RPM and Torque calculation of motor, Motor Controllers, Component sizing, Physical locations, Mechanical connection of motor, Electrical connection of motor.

Text Books:

1. Electric and Hybrid Vehicles: Design Fundamentals by Iqbal Husain, CRC Press
2. “Modern Electric Hybrid Electric and Fuel Vehicles” by Mehrdad Ehsani, Yimin Gao, Stefane Longo, Kambiz Ebrahimi., CRC Press, 3rd Edition.

22ME40B8 – INDUSTRY 4.0

L-T-P-S : 3-0-0-0
Credits : 3
Contact Hours : 3
Pre-requisites : NIL

Mapping of Course Outcomes with PO/PSO:

CO#	Course outcome	PO/PSO	BTL
CO1	Understand the drivers and enablers of Industry 4.0.	PO3, PO4	2
CO2	Appreciate the smartness in Smart Factories, Smart cities, smart products and smart services	PO3, PO4	2
CO3	Able to outline the various systems used in a manufacturing plant and their role in an Industry 4.0 world	PO3, PO4	2
CO4	Appreciate the power of Cloud Computing in a networked economy	PO3, PO4	2

Syllabus:

Introduction to Industry 4.0:

The Various Industrial Revolutions, Digitalisation and the Networked Economy, Drivers, Enablers, Compelling Forces and Challenges for Industry 4.0, The Journey so far: Developments in USA, Europe, China and other countries, Comparison of Industry 4.0 Factory and Today's Factory, Trends of Industrial Big Data and Predictive Analytics for Smart Business Transformation.

Road to Industry 4.0:

Internet of Things (IoT) & Industrial Internet of Things (IIoT) & Internet of Services, Smart Manufacturing, Smart Devices and Products, Smart Logistics, Smart Cities, Predictive Analytics.

Related Disciplines, System, Technologies for enabling Industry 4.0: Cyber physical Systems, Robotic Automation and Collaborative Robots, Support System for Industry 4.0, Mobile Computing, Related Disciplines, Cyber Security.

Role of data, information, knowledge and collaboration in future organizations: Resource-based view of a firm, Data as a new resource for organizations, Harnessing and sharing knowledge in organizations, Cloud Computing Basics, Cloud Computing and Industry 4.0.

Text books:

1. Artificial Intelligence a Modern Approach by Peter Norvig, Rusell

Reference Books:

2. Internet of Things – A hands-on approach", Arshdeep Bahga and Vijay Madisetti
3. Architecting for the Cloud-AWS Best Practices

22ME40B9 – INDUSTRIAL AUTOMATION

L-T-P-S : 3-0-0-0
Credits : 3
Contact Hours : 3
Pre-requisites : NIL

Mapping of Course Outcomes with PO/PSO:

CO#	Course outcome	PO/PSO	BTL
CO1	Explain the General function of Industrial Automation	PO3	2
CO2	Identify Safety in Industrial Automation,	PO3	2
CO3	Identify and understand the types of Industrial Sensors	PO3	2
CO4	Identify Practical Programmable Logic Controller Applications	PO3	2

Syllabus:

Evolution of Robotics and Automation: Robotics in science fiction, industrial revolution, history and need of robotics, definition of a robot, robot terminology, types and applications of robot, overview of present status and future trends, robotics market and future prospects.

Industrial Automation: Reasons for automation, arguments for and against automation, type of Industries and components of automation.

Types of Industrial Sensors: Optical, Inductive, Capacitive, Encoders, Ultrasonic, Thermocouples, Demonstrate Proper Wiring Techniques and Practical Applications.

Programmable Logic Controller: Introduction to PLC, Need of PLC in Designing, Architecture of PLC, Application and Advantage of PLC, Automation Concept And Basic Design, PLC Programming.

Text Books:

1. Terry Bartlet, “Industrial Control Electronics Devices, Systems, & Applications”, 3rd Edition, Delmar Publisher.

22ME40C1 – LOGISTICS & SUPPLY CHAIN MANAGEMENT

L-T-P-S : 3-0-0-0
Credits : 3
Contact Hours : 3
Pre-requisites : NIL

Mapping of Course Outcomes with PO/PSO:

CO#	Course outcome	PO/PSO	BTL
CO1	Understand the primary differences between logistics and supply chain management	PO11	2
CO2	Know the basic concepts of SCM and list out the important drivers of SC.	PO11	2
CO3	Understand the importance of SC drivers and their influence on SC performance	PO11	2
CO4	Able to apply the concepts of SCM on simple real time SC's	PO11	2

Syllabus:

Introduction to supply chain management: Supply chain basics (Definition of SC, Objectives of SC, SC stages, SC flows, SC Examples), decision phases in a supply chain (SC Strategy or Design, SC Planning and SC Operation), supply chain efficiency and responsiveness. Process view of a supply chain (Cycle view, Push/Pull View), Supply Chain Macro Processes in a firm, drivers of supply chain performance (Facilities, Inventory, Transportation, Information and Sourcing), Supply Chain performance: Competitive and supply chain strategies, achieving strategic fit.

Planning and Managing Inventories in a Supply Chain: Review of inventory concepts, Role of cycle inventory in a SC, Economies of scale to exploit fixed costs, Economics of scale to exploit quantity discounts, short-term discounting (Trade promotions). Role of safety inventory in a SC, safety inventory determination, Impact of supply uncertainty, aggregation and replenishment policies on safety inventory.

Designing distribution networks in a SC: Role of distribution in the SC, factors influencing distribution network design, Design options for distribution network, E-Business and the distribution network.

Transportation in a SC: Role of Transportation in a SC, Modes of transportation and their performance characteristics, Design options for a transportation network, tailored transportation, Trade-offs in transportation design, Risk management in transportation.

Sourcing decisions in a SC: Role of sourcing in a SC, In-house and Outsource, supplier scoring & assessment, Supplier selection – Auctions and Negotiations, Contracts, Role of IT in sourcing. **Pricing and Revenue Management in a SC:** Role of Pricing and Revenue Management in a supply chain, Pricing and Revenue management for Multiple customer segments, perishable assets, seasonal demand, bulk and spot contracts, Role of IT in pricing and revenue management.

Information Technology in a SC: The role of IT in a Supply Chain, The Supply Chain IT framework, CRM, ISCM, SRM, Transaction Management Foundation (TMF), Future of IT in 24 SC, The role of E-business in a supply chain, E-business framework, E-business in practice, Case discussion. Co-ordination in a SC: Lack of SC Co-ordination and the Bullwhip effect, effect on performance of lack of co-ordination, Obstacles to Co-ordination in a SC.

Text Books:

1. Supply Chain Management by S. Chopra and P. Meindl, Prentice Hall, 2010 (4th Edition)
2. Supply Chain Management – Strategy, Planning & Operation. Sunil Chopra & Peter Meindl; Pearson Education Asia,

Reference Books:

1. Supply Chain Redesign – Transforming Supply Chains into Integrated Value Systems - Robert B Handfield, Ernest L Nichols - Jr., 2002, Pearson Education Inc.
2. Modelling the Supply Chain -Jeremy F Shapiro, Duxbury -Thomson Learning -2002.
3. Designing & Managing the Supply Chain -David Simchi Levi, Philip Kaminsky& Edith Simchi Levi -McGraw Hill.

22ME40C2 – TOTAL QUALITY MANAGEMENT

L-T-P-S : 3-0-0-0
Credits : 3
Contact Hours : 3
Pre-requisites : NIL

Mapping of Course Outcomes with PO/PSO:

CO#	Course outcome	PO/PSO	BTL
CO1	Learn the principles and practices of TQM.	PO11	2
CO2	Know the evolution and challenges made in industries by TQM.	PO11	2
CO3	Understand the models to solve the problems and improving the circumstances.	PO11	2
CO4	Learn the quality tools implemented in industries and its performances.	PO11	2

Syllabus:

Principles and Practice: Definition of TQM, basic approach, Obstacles to TQM, TQM Framework, benefits of TQM. **Business Evolution:** Customer Satisfaction, four fitness of Customer Satisfaction, Evolution of Customer Satisfaction Methodology, Leadership vs Empowerment, Four Practical Revolutions in Management thinking, Four Levels of Practice.

Customer Focus: Change in the Work Concept: Market-in, Philosophy-in and Philosophy-out, Evolution of Customer Focus and Its Challenges, Three Stages of Customer Focus, Customer Concerns, Integration of Concerns, Individualizing Customers.

Continuous Improvement: Management by process, WV Model of Continuous Improvement, Three types of improvements, Continuous Improvement of Processes for All Types of Work, Continuous Improvement verses breakthrough, Continuous Improvement and the Scientific Method. **Managing Existing Processes:** Process Discovery and Management: Thinking In Terms of Process, Process Discovery, steps of Process Discovery, benefits of Process Discovery. The 7 QC Tools. **Proactive Improvement:** Proactive Improvement concept, Kawakita's Five Principles, Language Data and Use of Semantics, Comparison of Affective and Report language, Five principles of Customer Visitation, The purpose of Proactive Improvement to Develop New Products. **Total Participation:** Employee Involvement – Motivation, employee surveys, empowerment, teams, suggestion system, recognition and reward, gain sharing, performance appraisal, unions and employee involvement, three sets of skills of leader ship. QC Circles.

Text Books:

1. "Total Quality Management"- Besterfield, Pearson Education, 2011. ISBN, 817758412X, 9788177584127.

Reference Books:

1. "Management for Total Quality" -N Logothetis- Prentice Hall of India, New Delhi, 2003.
2. "Total Quality Management"-H D Ramachandra and K R Phanesh-2006 edition.

22ME40C3 – SMART MOBILITY

L-T-P-S : 3-0-0-0
Credits : 3
Contact Hours : 3
Pre-requisites : NIL

Mapping of Course Outcomes with PO/PSO:

CO#	Course outcome	PO/PSO	BTL
CO1	Able to appreciate the advantages of ITS	PO3	2
CO2	Able to suggest the appropriate technologies for field conditions.	PO3	2
CO3	Able to suggest the appropriate system/s in various functional areas of transportation	PO3	2
CO4	Able to amalgamate the various systems, plan and implement the applications of ITS	PO3	2

Syllabus:

Introduction to Intelligent Transportation Systems (ITS) – Definition, Objectives, Historical Background, Benefits of ITS -ITS Data collection techniques – Detectors, Automatic Vehicle Location (AVL), Automatic Vehicle Identification (AVI), Geographic Information Systems (GIS), video data collection.

Telecommunications in ITS - Information Management, Traffic Management Centres (TMC). Application of sensors to Traffic management; Traffic flow sensor technologies; Transponders and Communication systems; Data fusion at traffic management centres; Sensor plan and specification requirements; Elements of Vehicle Location and Route Navigation and Guidance concepts.

ITS functional areas – Advanced Traffic Management Systems (ATMS) , Advanced Traveler Information Systems (ATIS), Commercial Vehicle Operations (CVO), Advanced Vehicle Control Systems (AVCS), Advanced Public Transportation Systems (APTS), Advanced Rural Transportation Systems (ARTS). ITS User Needs and Services – Travel and Traffic management, Public Transportation Management, Electronic Payment, Commercial Vehicle Operations, Emergency Management, Advanced Vehicle safety systems, Information Management.

ITS Operations – Regional and Project ITS architecture; Concept of operations; ITS Models and Evaluation Methods; Planning and human factor issues for ITS, Case studies on deployment planning and system design and operation; ITS and safety, ITS and security, ITS as a technology deployment program, research, development and business models, ITS planning Dept. of Civil Engineering 49 M. Tech. Transportation Engg. & Management.

ITS applications: Traffic and incident management systems; ITS and sustainable mobility, travel demand management, electronic toll collection, ITS and road-pricing; Transportation network operations; commercial vehicle operations; public transportation applications; Automated Highway

Systems- Vehicles in Platoons –ITS in World – Overview of ITS implementations in developed countries, ITS in developing countries.

Reference Books:

1. Choudury M A and Sadek A, “Fundamentals of Intelligent Transportation Systems Planning” Artech House.
2. Kan Paul Chen, John Miles, “Recommendations for Wor ld Road Association (PIARC)” ITS Hand Book 2000.
3. Sussman, J. M., “Perspective on ITS”, Artech House Publishers, 2005.
4. Turban. E and Aronson. J. E, “Decision Support Sys tems and Intelligent Systems”, Prentice Hall

22ME40C4 – MANAGERIAL ECONOMICS FOR ENGINEERS

L-T-P-S : 3-0-0-0
Credits : 3
Contact Hours : 3
Pre-requisites : NIL

Mapping of Course Outcomes with PO/PSO:

CO#	Course outcome	PO/PSO	BTL
CO1	Apply the appropriate engineering economics analysis method(s) for problem solving: present worth, annual cost, rate-of-return, payback, break-even, benefit-cost ratio	PO11	3
CO2	Evaluate the cost effectiveness of individual engineering projects using the methods learned and draw inferences for the investment decisions	PO11	3
CO3	Compute the depreciation of an asset using standard depreciation techniques to assess its impact on present or future value	PO11	3
CO4	Apply all mathematical approach models covered in solving engineering economics problems	PO11	3

Syllabus:

Introduction to Engineering Economics: Introduction to Economics- Flow in an economy, Law of supply and demand, Concept of Engineering Economics – Engineering efficiency, Economic efficiency, Scope of engineering economics- Element of costs, Marginal cost, Marginal Revenue, Sunk cost, Opportunity cost, Break-even analysis, Elementary economic Analysis

Value Engineering: Make or buy decision, Value engineering – Function, aims, value engineering procedure. Interest formulae and their applications –Time value of money, Single payment compound amount factor, Single payment present worth factor, Equal payment series sinking fund factor, Equal payment series payment Present worth factor- equal payment series capital recovery factor-Uniform gradient series annual equivalent factor, Effective interest rate, Examples in all the methods.

Cash Flow: Methods of comparison of alternatives – present worth method (Revenue dominated cash flow diagram), Future worth method (Revenue dominated cash flow diagram, cost dominated cash flow diagram), Annual equivalent method (Revenue dominated cash flow diagram, cost dominated cash flow diagram), rate of return method, Examples in all the method

Replacement and Maintenance Analysis: Introduction-Types of maintenance –types of replacement Problem-Determination of economic life of an asset-Replacement of existing asset with a new asset. Depreciation- Introduction, Straight line method of depreciation, declining balance method of depreciation-Sum of the years digits method of depreciation, sinking fund method of depreciation/ Annuity method of depreciation, service output method of depreciation-Evaluation of public alternatives- introduction.

Text Books:

1. Dr. K K Patra, Dhiraj Bhattacharjee, Engineering Economics and Costing, S. Chand & Company Ltd, New Delhi, 2013.
2. Panneer Selvam, R., ***Engineering Economics***, Prentice Hall of India Ltd, New Delhi, 2001.

Reference Books:

1. Chan S.Park, ***Contemporary Engineering Economics***, Prentice Hall of India, 2002. Donald.G. Newman, Jerome.P.Lavelle, ***Engineering Economics and analysis*** Engg. Press, Texas, 2002.
2. Degarmo, E.P., Sullivan, W.G and Canada, J.R, ***Engineering Economy***, Macmillan, New York, 1984.
3. William G. Sullivan, Elin M Wicks, and James Luxhoj, Engineering Economy, 13th edition (Prentice-Hall)

Management Elective

22ME3217 Operations Management

L-T-P-S : 3-0-0-0
Credits : 3
Contact Hours : 3
Pre-requisite : Nil

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand about Production planning and predict future demand	PO2, PSO1	2
CO2	Apply various production scheduling and sequencing techniques to optimize productivity	PO1, PSO2	3
CO3	Apply Material Management and control techniques	PO4, PSO2	3
CO4	Apply various quality management and Lean management to various cases	PO4, PSO1	3

Syllabus:

Production Planning and Control

Forecasting models: Definition, Approaches, and Types, Qualitative Approach: Judgmental Methods, Quantitative Approach: Time Series, Regression, Multiple Regression, Forecasting Error Estimation Techniques aggregate production planning

Scheduling: Introduction, Concept of Assembly line balancing, Scheduling of Batch Production, Scheduling of Job Order, Loading.

Sequencing: Definition, Sequencing of n jobs through one machine, n jobs through 2 machines (Johnsons' algorithm), n jobs through 3 machines, n jobs through m machines materials requirement planning; lean manufacturing.

Materials Management - Inventory Control: Deterministic models; safety stock inventory control systems.

Quality management - Lean management

Text Books:

1. Groover, M.P. and Zimmers, JR E.R.,"CAD/CAM: Computer-Aided Design and Manufacturing", Prentice Hall 1983
2. Bewoor, A.K. and Kulkarni,V.A.,"Metrology and Measurement", Tata Mc Graw-Hill, 2009
3. R. Pannerselvam, Production and Operations Management, PHI Learning Pvt. Ltd., 3rd Edition, 2012.

Reference Books:

1. Mahapatra, P.B.," Computer-Aided Production Management", Prentice-Hall Of India Pvt. Limited, 2004
2. Gupta, I.C., "A Text Book of engineering metrology", Dhanpat Rai and Sons, 1996.
3. S.N. Chari, Production and Operations Management, Tata McGraw Hill, 3rd Edition, 2007.