NATIONAL INSTITUTE OF TECHNOLOGY ANDHRA PRADESH

SCHEME OF INSTRUCTION AND SYLLABI

B.Tech. – Mechanical Engineering

Effective from 2020-21

Contents

Vision of the Department of ME:

To impart professional education in mechanical engineering to become successful entrepreneurs capable of developing innovative, interdisciplinary and sustainable globally competitive technologies and nurture the students as responsible citizens service to the society.

Mission of the Department of ME:

M 1. To impart mechanical engineering education with latest teaching learning processes.
M 2. To equip the students with the advanced tools to make them suitable for global employment and societal requirements.
M 3. To train the students to solve engineering problems in multi-disciplinary areas.
M 4. To inculcate professional ethics and human values.

Programme Educational Objectives (PEOs) for the B.Tech. (ME) Programme:

Within few years after the end of the B.Tech. in Mechanical Engineering programme, graduates will be able to:

PEO1	Plan, design, construct, maintain and improve mechanical engineering systems that are technically sound, economically feasible and socially acceptable to enhance quality of life.
PEO2	Apply modern computational, analytical, simulation tools and techniques to address the challenges faced in mechanical and allied engineering streams.
PEO3	Communicate effectively using innovative tools and demonstrate leadership & entrepreneurial skills.
PEO4	Exhibit professionalism, ethical attitude, team spirit and pursue lifelong learning to achieve career and organizational goals.

Programme Articulation Matrix (PEO vs. Mission) for the B.Tech. (ME) Programme:

PEO\Mission	**M1**	**M2**	**M3**	**M4**
PEO1	S	M	M	L
PEO2	M	S	M	L
PEO3	M	M	S	L
PEO4	L	L	M	S

S: Strong correlation, M: Medium correlation, L: Low correlation

Programme Outcomes (POs) for the B.Tech. (ME) Programme:

At the end of any B.Tech. program in NIT Andhra Pradesh, graduates will be able to:

PO1	**Engineering knowledge**: Apply knowledge of mathematics, science and engineering to analyze, design and evaluate mechanical components & systems using state -of-the-art IT tools.
PO2	**Problem analysis**: Analyze problems of mechanical engineering including thermal, manufacturing and industrial systems to formulate design requirements.
PO3	**Design/Development of solutions**: Design, implement, and evaluate mechanical systems and processes considering public health, safety, cultural, societal and environmental issues.
PO4	**Conduct investigations of complex problems:** Design and conduct experiments using domain knowledge and analyze data to arrive at valid conclusions.
PO5	**Modern tool usage**: Apply current techniques, skills, knowledge and computer based methods & tools to develop mechanical systems.
PO6	**The engineer and society**: Analyze the local and global impact of modern technologies on individual organizations, society and culture
PO7	**Environment and sustainability**: Apply knowledge of contemporary issues to investigate and solve problems with a concern for sustainability and eco friendly environment.
PO8	**Ethics**: Exhibit responsibility in professional, ethical, legal, security and social issues
PO9	**Individual and team work**: Function effectively in teams, in diverse and multidisciplinary areas to accomplish common goals.
PO10	**Communication**: Communicate effectively in diverse groups and exhibit leadership qualities.
PO11	**Project management and Finance**: Apply management principles to manage projects in multidisciplinary environment.
PO12	**Life-long learning**: Pursue life-long learning as a means to enhance knowledge and skills.

Programme Specific Outcomes (PSO) for the B.Tech. (ME) Programme:

At the end of the B.Tech. in Mechanical Engineering programme, graduates will be able to:

PSO1	Apply mechanical engineering and interdisciplinary knowledge for analyzing, designing and manufacturing products to address the needs of the society.
PSO2	Apply state of the art tools and techniques to conceptualize, design and introduce new products, processes, systems and services.
PSO3	Apply research-based methods to innovate, improve, and validate theoretical understandings for addressing the needs of industries and the society.

Degree Requirements for B.Tech. (ME) Programme

	Proposed Credits (New regulation)
Basic Science Core (BSC)	**19 (11.72%)**
Engineering Science Core (ESC)	**17 (10.49%)**
Humanities and Social Science Core (HSC)	**06 (3.7%)**
Program Core Courses (PCC)	**69 (42.59%)**
Departmental Elective Courses (DEC)	**15 (9.25%)**
Open Elective Courses (OPC)	**09 (5.55%)**
Program Major Project (PRC)/Skill Development (SD)/Foreign Languages	**21 (12.96%)**
EAA: Games and Sports (MSC)	**2 (1.23%)**
MOOCs (MOE)	**4 (2.46%)**
Total	**162**

Choice Based Credit System: 25.92 %

NOTE: The minimum no. of credits required to award B.Tech. degree is 162 as per the proposed curriculum.

Credit Distribution in Each Semester										
	I	II	III	IV	V	VI	VII	VIII	TOT	REQ
BSC	8	8	0	3	0	0	0	0	**19**	**≥ 19**
ESC	4	10	3	0	0	0	0	0	**17**	**≥ 14**
HSC	3	0	0	0	0	3	0	0	**6**	**≥ 06**
PCC	0	0	17	17	16	8	11	0	**69**	**≥ 62**
DEC	0	0	0	0	0	6	6	3	**15**	**≥ 15**
OPC	0	0	0	0	3	3	0	3	**9**	**≥ 09**
PRC/ SD	5	2	0	2	0	3	3	6	**21**	**≥ 15**
EAA (MSC)	1	1	0	0	0	0	0	0	**2**	**≥ 2**
MOOCS (MOE)	0	0	0	0	2	0	0	2	**4**	**≥ 4**
	21	**21**	**20**	**22**	**21**	**23**	**20**	**14**	**162**	

I Year B.Tech. Course Structure

(Common for all branches)

Physics Cycle							
S. No.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**	**Cat. Code**
1	MA101/ MA151	Differential and Integral Calculus / Matrices and Differential Equations	3	0	0	**03**	**BSC**
2	HS101	English for Technical Communication	2	0	2	**03**	**HSC**
3	PH101	Engineering Physics	3	0	0	**03**	**BSC**
4	EC101	Basic Electronic Engineering	2	0	0	**02**	**ESC**
5	CE102	Environmental Science and Engineering	2	0	0	**02**	**ESC**
6	CS101	Introduction to Algorithmic Thinking and Programming	3	0	0	**03**	**SD**
7	CS102	Introduction to Algorithmic Thinking and Programming Lab	0	1	2	**02**	**SD**
8	PH102	Engineering Physics Lab	0	1	2	**02**	**BSC**
9	EA101/ EA151	Physical Education/Health Education	0	0	3	**01**	**MSC**
		TOTAL	**15**	**2**	**9**	**21**	

Chemistry Cycle							
S. No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**	**Cat. Code**
1	MA101/ MA151	Differential and Integral Calculus / Matrices and Differential Equations	3	0	0	**03**	**BSC**
2	ME102	Engineering Graphics with Computer Aided Drafting	0	1	2	**02**	**ESC**
3	CY101	Engineering Chemistry	3	0	0	**03**	**BSC**
4	EE101	Elements of Electrical Engineering	2	0	0	**02**	**ESC**
5	BT101	Biology for Engineers	2	0	0	**02**	**ESC**
6	ME101	Basics of Mechanical Engineering	2	0	0	**02**	**ESC**
7	CE101	Engineering Mechanics	2	0	0	**02**	**ESC**
8	ME103	Workshop Practice	0	1	2	**02**	**SD**
9	CY102	Engineering Chemistry Lab	0	1	2	**02**	**BSC**
10	EA101/ EA151	Physical Education/Health Education	0	0	3	**01**	**MSC**
		TOTAL	**14**	**3**	**9**	**21**	

Note:

BSC: Basic Science Core	ESC: Engineering Science Core
HSC: Humanities and Social Science Core	PCC: Program Core Courses
DEC: Departmental Elective Courses	OPC: Open Elective Courses
Program Major Project (PRC)/Skill Development (SD)/Foreign Languages	EAA (MSC): Games and Sports MOOCs (MOE)

Summer Internship – I#

II Year B.Tech. ME Course Structure

Semester-III							
S. No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**	**Cat. Code**
1	MM235	Materials Engineering	3	0	0	**03**	**ESC**
2	ME201	Engineering Thermodynamics	3	0	0	**03**	**PCC**
3	ME202	Kinematics of Machinery	3	0	0	**03**	**PCC**
4	ME203	Production Processes & Management	3	0	0	**03**	**PCC**
5	ME204	Mechanics of Materials	3	0	0	**03**	**PCC**
6	ME205	Fluid Mechanics and Hydraulic Machines	3	0	0	**03**	**PCC**
7	ME206	Materials Testing Laboratory	0	0	2	**01**	**PCC**
8	ME207	Fluid Mechanics and Hydraulics Machines Laboratory	0	0	2	**01**	**PCC**
		TOTAL	**18**	**4**	**4**	**20**	

Semester-IV							
S. No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**	**Cat. Code**
1	MA252	Transformation Techniques	3	0	0	**03**	**BSC**
2	ME251	Dynamics of Machinery	2	1	0	**03**	**PCC**
3	ME252	Turbomachines	2	1	0	**03**	**PCC**
4	ME253	Geometric Modeling for CAD	3	0	0	**03**	**PCC**
5	ME254	Mechanical Measurements and Metrology	3	0	0	**03**	**PCC**
6	ME255	Industrial Engineering	3	0	0	**03**	**PCC**
7	ME256	Production Processes Laboratory	0	0	2	**01**	**PCC**
8	ME257	Kinematics and Dynamics Laboratory	0	0	2	**01**	**PCC**
9	ME299	Mini Project – I (EPICS based)	0	0	4	**02**	**SD**
		TOTAL	**18**	**2**	**8**	**22**	

Summer Internship – II#

III Year B.Tech. ME Course Structure

Semester-V							
S. No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**	**Cat. Code**
1	ME301	Design of Machine Elements	3	0	0	**03**	**PCC**
2	ME302	Prime Movers and Hybrid Vehicles	3	0	0	**03**	**PCC**
3	ME303	Computer Aided Machine Drawing	1	0	4	**03**	**PCC**
4	ME304	Machine Tools and Machining Science	3	0	0	**03**	**PCC**
5	ME305	IC Engines and Fuels Laboratory	0	0	4	**02**	**PCC**
6	ME306	Machining and Metrology laboratory	0	0	4	**02**	**PCC**
7		Open Elective – 1/Sanskrit-1/Foreign language elective	3	0	0	**03**	**OPC/SD**
8	MME301	MOOCs-1	2	0	0	**02**	**MOE**
		TOTAL	**15**	**1**	**10**	**21**	

Semester-VI							
S. No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**	**Cat. Code**
1		Department Elective –1	3	0	0	**03**	**DEC**
2		Department Elective – 2	3	0	0	**03**	**DEC**
3	ME351	Design of Transmission Elements	2	1	0	**03**	**PCC**
4	ME352	Heat and Mass Transfer	2	1	0	**03**	**PCC**
5	SM351	Engineering Economics and Accountancy	3	0	0	**03**	**HSC**
6	ME353	Heat Transfer Laboratory	0	0	2	**01**	**PCC**
7	ME354	Measurements Laboratory	0	0	2	**01**	**PCC**
8		Open Elective – 2/Sanskrit-1/Foreign language elective	3	0	0	**03**	**OPC/SD**
9	ME399	Mini Project - II	0	0	6	**03**	**SD**
		TOTAL	**18**	**1**	**10**	**23**	

Summer Internship – III#

#: The student can do Summer Internship with duration of minimum 45 days at Institutes / Organizations / Industries and produce the certificate of completion and copy of internship report to the department.

It is optional only, Not Mandatory.

IV Year B.Tech. ME Course Structure

Semester-VII							
S. No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**	**Cat. Code**
1	ME401	Mechatronics	3	0	0	**03**	**PCC**
2		Department Elective – 3	3	0	0	**03**	**DEC**
3		Department Elective – 4	3	0	0	**03**	**DEC**
4	ME402	Refrigeration and Air-conditioning	3	0	0	**03**	**PCC**
5	ME403	Computer Aided Manufacturing	3	0	0	**03**	**PCC**
6	ME404	CAE and CAM Lab	0	0	2	**01**	**PCC**
7	ME405	Mechatronics Lab	0	0	2	**01**	**PCC**
8	ME449	Project-Work Part - A	0	0	6	**03**	**PRC**
		TOTAL	**14**	**0**	**10**	**20**	

**: The PCC Subject may be offered with the support of Industry.

Semester-VIII							
S. No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**	**Cat. Code**
1		Department Elective – 5*	3	0	0	**03**	**DEC**
2		Open Elective – 3*	3	0	0	**03**	**OPC**
3	MME451	MOOCs-2	2	0	0	**02**	**MOE**
4	ME499	Project-Work Part – B (with option of Industrial Training/Internship)	0	0	12	**06**	**PRC**
		TOTAL	**8**	**0**	**12**	**14**	

*If the students are in Industrial training, the electives may be conducted online.

List of Electives

Classification of Electives:

1: Manufacturing Engineering

2: Thermal Engineering

3: Design Engineering

III Year – II semester

Course Code	Elective name (DE-1)	credits	Elective class
ME361	Advanced Thermodynamics	3-0-0	2
ME362	Gas Dynamics	3-0-0	2
ME363	Automobile Engineering	3-0-0	2
ME364	Advanced Welding Technology	3-0-0	1
ME365	Tool Design and Engineering	3-0-0	3
ME366	Non-Destructive Testing	3-0-0	1
ME367	Mechanical Vibrations	3-0-0	3
ME368	Design Optimization Methods	3-0-0	1,3
ME369	Finite Element Method	3-0-0	3
ME370	Management Science and Productivity	3-0-0	1
Course Code	**Elective name (DE-2)**	**credits**	**Elective class**
ME371	Computational Fluid Dynamics	3-0-0	2
ME372	Advanced IC Engines	3-0-0	2
ME373	Convective Heat Transfer	3-0-0	2
ME374	Advanced Metal Casting	3-0-0	1
ME375	Design for Manufacturing and Assembly	3-0-0	1,3
ME376	Machine Tool Design	3-0-0	3
ME377	Theory of Elasticity	3-0-0	3
ME378	Design and Analysis of Experiments	3-0-0	1,3
ME379	Tribology	3-0-0	3
ME380	Production Planning and Control	3-0-0	1

IV Year – I Semester

Course Code	Elective name (DE-3)	credits	Elective class
ME411	Jet Propulsion and Rocketry	3-0-0	2
ME412	HVAC	3-0-0	2
ME413	Cryogenics	3-0-0	2
ME414	Micro and Nano Manufacturing	3-0-0	1
ME415	Advanced Metal forming	3-0-0	1
ME416	Design and Analysis of Engineering Materials	3-0-0	1
ME417	Condition Monitoring	3-0-0	1,3
ME418	Theory of Plasticity	3-0-0	3
ME419	Robotics	3-0-0	3
ME420	Total Quality Management	3-0-0	1
Course Code	**Elective name (DE-4)**	**credits**	**Elective class**
ME421	Micro-scale Heat Transfer	3-0-0	2
ME422	Power Plant Engineering	3-0-0	2
ME423	Fuels and Combustion	3-0-0	2
ME424	Additive Manufacturing	3-0-0	1
ME425	Industrial Automation	3-0-0	1
ME426	Advanced Materials Processing	3-0-0	1
ME427	Rotor Dynamics	3-0-0	3
ME428	Engineering Acoustics	3-0-0	3
ME429	Mechanics of Composite Materials	3-0-0	3
ME430	Operations Research	3-0-0	1

IV Year – II Semester

Course Code	Elective name (DE-5)	credits	Elective class
ME461	Alternative Fuels and Energy Systems	3-0-0	2
ME462	Radiation Heat Transfer	3-0-0	2
ME463	Reliability Engineering	3-0-0	3
ME464	Product Life Cycle Management	3-0-0	1
ME465	Flexible Manufacturing Systems	3-0-0	1
ME466	Laser Processing of Materials	3-0-0	1
ME467	Innovative Design	3-0-0	3
ME468	Theory of Constraints	3-0-0	3
ME469	Advanced Operations Research	3-0-0	1
ME470	Supply Chain Management	3-0-0	1

Course Code	Open Elective-1	credits	Elective class
ME340	Automotive Mechanics	3-0-0	2
ME341	New Venture Creation	3-0-0	1
	Open Elective-2		
ME390	Alternate Sources of Energy	3-0-0	2
ME391	Robust Design	3-0-0	3
	Open Elective-3		
ME490	Entrepreneurship	3-0-0	1,2,3
ME491	Project Management	3-0-0	1,2,3

Minor in Automation and Robotics: Course Structure

S. No.	Course Code	Course Title	L	T	P	Credits	Offered Sem
1	MEM251	Mechanisms and Machines	3	0	0	**03**	**4th**
2	MEM301	Automation Technologies in Industries	3	0	0	**03**	**5th**
3	MEM351	Mechatronic Systems	3	0	0	**03**	**6th**
4	MEM352	Mechatronics Lab	0	0	3	**02**	**6th**
5	MEM401	CNC and Robotics	3	0	0	**03**	**7th**
6	MEM402	CNC and Robotics Lab	0	0	3	**02**	**7th**
		TOTAL	**12**	**0**	**06**	**16**	

Honors in Mechanical Engineering: Course Structure

S. No	Course Code	Course Title	L	T	P	Credits	Offered sem
1	MEH301	Computational Methods in Mechanical Engineering	3	1	0	**04**	**5th**
2	MEH302	Artificial Intelligence and Machine learning	3	1	0	**04**	**5th**
3	MEH351	Characterization of Materials	3	1	0	**04**	**6th**
4	MEH352	Servitization	3	1	0	**04**	**6th**
5	MEH401	Advanced Manufacturing Processes	3	1	0	**04**	**7th**
		TOTAL	**15**	**5**	**0**	**20**	

Note:

1. A student is permitted to do either Minor or Honors only, but not both
2. A student is permitted to do only one Minor/ one Honors.

I Year B.Tech. Course Structure

(Common for All Branches)

MA101	**Differential and Integral Calculus** I B.Tech. I Semester - all sections	BSC	3-0-0	3 Credits

Pre-requisites: None

Differential Calculus of functions of several variable: Review of Limit, continuity (sequential verification) and differentiability, Partial differentiation; Total differentiation; Euler's theorem and generalization; Change of variables- Jacobians; Maxima and minima of functions of several variables (2 and 3 variables); Lagrange's method of multipliers. (14)

Integral Calculus: Convergence of improper integrals; Beta and Gamma integrals; Differentiation under integral sign; Double and Triple integrals - computation of surface areas and volumes; change of variables in double and triple integrals. (14)

Vector Calculus: Scalar and vector fields; vector differentiation; level surfaces; directional derivative; gradient of a scalar field; divergence and curl of a vector field; Laplacian; Line and Surface integrals; Green's theorem in a plane; Stokes' theorem; Gauss Divergence theorem. (14)

Text Reference:

1. Joel R. Hass, Maurice D. Weir, George B. Thomas, Thomas' Calculus, 12th edition, Pearson , 2010.
2. Erwin Kreyszig, *"Advanced Engineering Mathematics"*, Eighth Edition, John Wiley and Sons, 2015
3. B. S. Grewal, *"Higher Engineering Mathematics"*, Khanna Publications, 2015
4. R. K. Jain and S. R. K. Iyengar, *"Advanced Engineering Mathematics"*, Fifth Edition, Narosa Publishing House, 2016.
5. T. M. Apostol, Calculus, Volumes 1 and 2 (2nd Edition), Wiley Eastern, 1980.

MA151	**Matrices and Differential Equations** I B.Tech. II Semester - all sections	BSC	3-0-0	3 Credits

Pre-requisites: Mathematics-I

Matrix Theory: Linear dependence and independence of vectors; Rank of a matrix; Consistency of the system of linear equations; Eigenvalues and eigenvectors of a matrix; Caley-Hamilton theorem and its applications; Reduction to diagonal form; Reduction of a quadratic form to canonical form - orthogonal transformation; Properties of complex matrices - Hermitian, skew-Hermitian and Unitary matrices. (14)

Ordinary Differential Equations of Higher Order : Higher order linear differential equations with constant coefficients - homogeneous and non-homogeneous; Euler and Cauchy's differential equations; Method of variation of parameters; System of linear differential equations; applications in physical problems - forced oscillations, electric circuits, etc. (14)

Laplace Transforms: Laplace transforms; inverse Laplace transforms; Properties of Laplace transforms; Laplace transforms of unit step function, impulse function, periodic function; Convolution theorem, Solving certain initial value problems, Solving system of linear differential equations, Finding responses of systems to various inputs viz. sinusoidal inputs acting over a time interval, rectangular waves, impulses etc. (14)

Text Reference:

1. E. Kreyszig, Advanced Engineering Mathematics, Eighth Edition, John Wiley and Sons, 2015.
2. B. S. Grewal, Higher Engineering Mathematics, Khanna Publications, 2015.
3. R. K. Jain and S. R. K. Iyengar, Advanced Engineering Mathematics, Fifth Edition, Narosa Publishing House, 2016.
4. G. Strang, Linear Algebra and Its Applications, 4th Edition, Brooks/Cole India, 2006.
5. T. M. Apostol, Calculus, Volume 2 (2nd Edition), Wiley Eastern, 1980.

HS101	ENGLISH FOR TECHNICAL COMMUNICATION	SD	2 – 0 – 2	3 Credits

Pre-requisites: None.

Detailed syllabus

Grammar Principles and Vocabulary Building: -Exposure to basics of grammar- tenses—active and passive voice- their usage-Concord -Error Detection-Idioms and Phrases-Phrasal verbs—their meanings and usage, Synonyms and antonyms

Developing paragraphs using mind mapping- Definition- structure- Types and Composition-unity of theme- coherence- organization patterns-essays and their structure- note-making

Letter Writing: Formal letters-- communicative purpose-strategy- letter format and mechanics- letters of request, complaint and invitation-writing emails
Reading Comprehension –skimming-scanning-intensive and extensive reading-reading to retrieve information ––techniques of comprehension -find clues to locate important points- answering objective type questions–inference, elimination

Delegation- steps involved in delegation-preparing delegation for a program
Preparing Questionnaire-Determine audience and content of each question-response structure-develop wording for each question-establish sequence of questions

Profiling Readers-Audience analysis- Identifying potential audience- Identifying primary, secondary, tertiary readers,and gatekeepers- Identifying the needs, values, and attitude of the readers
Resume Writing-Writing for Professional Networking-Academic writing-research proposals-Interpretation of Graphs.

Technical Report-Writing - kinds of reports-proposals, progress and final reports- their structure- features- process of writing a report-editing.

Language Laboratory
Introduction to basic phonetics: Vowels, Consonants, Diphthongs, phonetic symbols
Listening: Challenges in listening, enhancing listening skills, listening activities
Speaking:JAM using cue cards-role play-Group presentation-presentation with emphasis on body language- public speaking-extempore speech
Group discussion: Dos and don’ts, intensive practice
Mock interview:Interview etiquette, common interview questions

Text Books:

Emden, Joan van. *Effective Communication for Science and Technology*. Macmillan Education UK, 2001.

Mohan, Krishna and Meera Banerji. *Developing Communication Skills*. Macmillan India Limited, 2000.

Murphy, Raymond. *Intermediate English Grammar*. Cambridge University Press, 2014.

Narayanaswami, V. R. *Strengthen Your Writing*. Orient Longman Private Limited, 2005.

Soundaraj, Francis. *Speaking and Writing for Effective Business Communication*. Macmillan Publishers India Limited, 2007.
Ur, Penny. *Discussions that Work*. Cambridge University Press, 1981.

Reference:

Aarts, Bas. *Oxford Modern English Grammar*. Oxford University Press, 2011.

Anderson, Marilyn, Pramod K. Nayar, and Madhucchanda Sen. *Critical Thinking, Academic Writing and Presentation Skills*. Pearson Education, 2008.

Blake,Gary.*The Elements of Technical Writing*. Pearson,2000

Brown, Carla L. *Essential Delegation Skills*. Routledge, 2017.

Busan, Tony. *Mind Map Mastery*. Walkins, 2018.

Carlisle, Joanne and Melinda S. Rice. *Improving Reading Comprehension Research-based Principles and Practices*. York Press, 2002.

Carter, Ronald and Michael McCarthy. *Cambridge Grammar of English: A Comprehensive Guide*. Cambridge University Press, 2006.

Carter, Ronald, Rebecca Hughes, and Michael McCarthy. *Exploring Grammar in Context: Upper-intermediate and Advanced.* Cambridge University Press, 2000.

Eastwood, John. *Oxford Guide to English Grammar*. Oxford University Press, 1994.

Harris, David.F. *Complete Guide to Writing Questionnaires.* I& M Press, 2014.

Hering, Lutz and Heike Hering. *How to Write Technical Reports: Understandable Structure, Good Design, Convincing Presentation*. Springer; 2010.

HuckinN.Thomas and Leslie A.Olsen*Technical Writing and Professional Communication for Non-native Speakers*. McGraw-Hill Education,1991.

Laplante, Phillip A*. Technical Writing: A Practical Guide for Engineers, Scientists, and Nontechnical Professionals.* CRC Press, 2018.

McQuail, Dennis. *Audience Analysis*. Sage, 1997

Ogden, Richard. *Introduction to English Phonetics*. Edinburgh University Press, 2017.

Parker, Glenn M. *Team Players and Teamwork: New Strategies for Developing Successful Collaboration*. Wiley, 2011.

Seely, John. *Oxford Guide to Effective Writing and Speaking: How to Communicate Clearly*. Oxford University Press: 2013.

PH101	Engineering Physics	BSC	3-0-0	3 Credits

Waves and Optics

Interference: Superposition principle, coherence of light, methods to produce coherent light: division of amplitude and wave front division, Young's double slit experiment: concept, working principle, and applications, Newton's ring: concept, working principle, and applications

Diffraction: Fraunhofer's single-slit diffraction, diffraction grating, and resolving power of a grating.

Polarization: Types of optical polarization, various methods to produce polarized light, working and applications of retarder plates, and half-shade polarimeter: construction and working principle.

Lasers and Optical Communication

LASER: Basic theory of LASER, Einstein's coefficients and their relations, concept of population inversion, components of lasers, modes of laser beam, construction and working principle of various types of lasers: Ruby, Helium-Neon, and semiconductor diode lasers.

Optical Fibre: Optical fibre and its working principle, total internal reflection, numerical aperture, modes of propagation, and classification of optical fibres.

Quantum Physics

Origin of quantum theory and related experiments: Black-Body radiation, photo-electric effect, and Compton effect. Heisenberg's uncertainty principle, de- Broglie's wave concept, phase and group velocities, wave function, and its properties, operators, Schrödinger's time-dependent and time-independent equations, particle in one-dimensional, infinite potential and finite potential wells, and quantum tunneling phenomena and their applications in alpha decay, and scanning tunneling microscopy (STM).

Magnetic, Superconducting and Dielectric Materials

Magnetic Materials: Introduction to Weiss theory of ferromagnetism, concepts of magnetic domains, Curie transition, hard and soft magnetic materials and their applications, magneto-resistance, GMR, and TMR.

Superconducting Materials: Introduction to superconductivity, Meissner effect, Type-I and Type-II superconductors and their applications.

Dielectric Materials: Introduction to dielectrics, dielectric constant, polarizability, frequency and temperature dependent polarization mechanism in dielectrics, dielectric loss, and applications.

Advanced Functional Materials & NDT

Smart Materials: Biomaterials, high-temperature materials and smart materials, applications of functional materials.

Nanomaterials: Introduction, classification, and properties of nanomaterials, various methods of synthesizing nanomaterials: top-down (ball milling) and bottom-up (sol-gel) approaches.

Photovoltaic Materials: Solar spectrum, photovoltaic effect, materials, structure and working principle, I-V characteristics, power conversion efficiency, quantum efficiency, emerging PV technologies, and applications.

NDT: Methods of non-destructive testing

References:

1. A Textbook of Engineering Physics, M. N. Avadhanulu, P. G. Kshirsagar, S. Chand and Company (2015).
2. Concepts of Modern Physics, Beiser A., Mc. Graw Hill Publishers (2003).
3. Optics, Ajoy Ghatak, Tata Mc Graw Hill (2012).
4. Materials Science and Engineering: An Introduction (Tenth edition), William D. Callister, John Wiley & Sons (2018).
5. Introduction to Solid State Physics, Charles Kittel, Wiley Publishers (2011).

EC101	**Basic Electronics Engineering**	**ESC**	**2 – 0 – 0**	**2 Credits**

Detailed Syllabus:

Introduction to electronics systems, diode circuit models and applications, Zener diode as regulator, photodiode.

Transistor and applications: Introduction to transistors, BJT Characteristics, biasing and applications. FET and MOSFET characteristics and applications.

Feedback in Electronic Systems: open loop and closed loop systems, Negative and positive Feedback, Principles of LC and RC oscillators.

Integrated Circuits: Operational amplifiers Characteristics and applications, linear operations using Op-amps.

Digital Circuits: Number systems and logic gates, Combinational Logic circuits, Sequential Circuits, Analog to Digital and Digital to Analog converters (ADC/DAC).

Laboratory measuring instruments: principles of digital multi-meters, Cathode ray oscilloscopes (CRO).

Reading:

1. Bhargava N. N., D C Kulshreshtha and S C Gupta, Basic Electronics & Linear Circuits, 2nd Edition, Tata McGraw Hill, 2013.
2. S. Sedra and K. C. Smith, Microelectronic Circuits, Oxford University Press , 6th Edition
3. Leach , Malvino, Saha, Digital Principles and Applications, McGraw Hill Education , 8th Edition
4. Boylestad, Robert L., Louis Nashelsky, Electronic Devices and Circuit, Pearson , 11th Edition
5. Helfrick and Cooper, ― Modern Electronic Instrumentation and Measurement Techniques‖ PHI, 2011
6. Neil Storey, Electronics A Systems Approach, 4th Edition, Pearson Education Publishing Company Pvt Ltd.

CE102	ENVIRONMENTAL SCIENCE AND ENGINEERING	ESC	2-0-0	2 Credits

Detailed Syllabus:

Introduction to Environmental Science: Environment and Societal Problems, Major Environmental Issues, Global Climate Change Agreements, Montreal, Kyoto Protocol & Paris Agreement, Basics of Environmental Impact Assessment, Principles of Sustainability, and related indices, Population Dynamics, Urbanization. Identification and Evaluation of Emerging Environmental Issues with Air, Water, Wastewater and Solid Wastes, Introduction to Environmental Forensics.

Water & Wastewater Treatment: Water Sources, constituents, potable water quality requirements (IS 10500), overview of water treatment, sources and types of pollutants, their effects, self-purification capacity of water bodies, principles of wastewater treatment, 5R Concept.

Air & Noise Pollution: Sources, classification and their effects, national ambient air quality standards (NAAQS), air quality index, dispersion of pollutants, control of air pollution, understanding and improving indoor air quality, sources of noise pollution, effects, quantification of noise pollution.

Solid Waste Management: Sources and characteristics of solid waste, effects, 3R concept, sustainable practices in waste management, CPHEEO guidelines for solid waste management, transition to zero waste lifestyle.

Reading:

1. G.B. Masters, Introduction to Environmental Engineering and Science, Pearson Education, 2013.
2. Gerard Kiely, Environmental Engineering, McGraw Hill Education Pvt Ltd, Special Indian Edition, 2007.
3. Benny Joseph, Environmental Science and Engineering, Tata McGraw-Hill, New Delhi, 2006.

References:

1. Peavy, H.S, Rowe, D.R., and G. Tchobanoglous (1985), Environmental Engineering, McGraw Hill Inc., New York
2. W P Cunningham, M A Cunningham, Principles of Environmental Science, Inquiry and Applications, Tata McGraw Hill, Eighth Edition, 2016.

CS101	Introduction to Algorithmic Thinking and Programming	SD	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Construct algorithms for solving problems that requires solutions involving searching, sorting, selection and / or a numerical method as a sub-routine.
CO2	Analyze the suitability of different algorithmic design paradigms for solving problems with an understanding of the time and space complexities incurred.
CO3	Construct algorithms for solving problems with an understanding of the internals of a computing system and its components like processor, memory and I/O sub-systems.
CO4	Construct efficient modular programs for implementing algorithms by leveraging suitable control structures.
CO5	Construct efficient programs by selecting and using suitable in-built Data Structures and programming language features available.

Course Articulation Matrix:

PO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	M	L									
CO2	S	M	L									
CO3	S	M	L		L							
CO4	S	M	L		S							
CO5	S	M	L		S							

S: Strong correlation, M: Medium correlation, L: Low correlation

Detailed Syllabus:

Fundamentals of Computers, Historical perspective, Early computers, Modern Computers, Hardware Components of a Computer, Data Representation in Computers, Introduction to Operating Systems, Software and Firmware, Problems, Flowcharts, Memory, Variables, Values, Instructions, Programs.

Problem solving techniques – Algorithmic approach, characteristics of algorithms, Problem solving strategies: Top-down approach, Bottom-up approach, Time and space complexities of algorithms, Algorithm Analysis.

Basic Syntax in Python, Data Types, Variables, Assignments, immutable variables, Types of Operators, Expressions, Comments, Boolean Logic, Logical Operators in Python.

Conditional statements - If-else, Loops - while, for, Lazy Evaluation

Inbuilt Data Structures and their operations in Python: List, Tuples and Dictionaries.

Fundamental Algorithms: Swapping variables, Problems involving summation of a series, Sine function computation, Base Conversion, generation of sequences like Fibonacci, Reversing the digits of an integer, Character to number conversion.

Factoring Methods: Finding the square root, Finding the smallest divisor of an integer, finding the greatest common divisor using Euclid's algorithm, Computing the prime factors of an integer, generating prime numbers, Raising a number to a large power, Computation of the nth Fibonacci number.

Functions – Modular programming and benefits, user defined functions, library functions, parameter passing, Formal and Actual arguments, named arguments return values, Recursion.

Sorting algorithms: Bubble, Selection and Insertion sorts, Search algorithms: Linear and binary search

String processing: Algorithms for implementing String functions like Strlen, Strcpy, StrRev, Strcmp, Searching for a keyword or pattern in a text.

File and Directory Handling: Reading and Writing to/from a file, Formatted File creation and operations.

Simple 2D Graphics, drawing 2D objects using Turtle Graphics.

Reading List:

1. Kenneth Lambert, Fundamentals of Python: First Programs, Cengage Learning, 2019
2. R.G. Dromey, how to solve it by Computer, Pearson, 2008.

CS102	**Introduction to Algorithmic Thinking and Programming Lab**	**SD**	**0 – 1 – 2**	**2 Credits**

Pre-requisites: None

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

CO1	Construct, debug, test and run efficient programs by leveraging suitable flow of control constructs and syntactic units of the programming language.
CO2	Construct efficient programs by constructing and translating algorithms for solving problems using sorting, searching, selection and / or arithmetic computations.
CO3	Implement, refactor, test and debug functional programs in a shell-based run time environment.
CO4	Construct efficient programs by demonstrating problem-solving skills and out-of-the-box algorithmic thinking.

Course Articulation Matrix:

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	S	M	L		S				M			L
CO2	S	M	L		S				M			L
CO3	S	M	L		S				M			L
CO4	S	M	L		S				M			L

S: Strong correlation, M: Medium correlation, L: Low correlation

Detailed Syllabus:

List of Experiments:

1. Familiarization with Python installation, basic syntax and running scripts in the shell.
2. Programs on conditional control constructs.
3. Programs on iterative constructs. (While, do-while, for).
4. Programs using user defined functions and in-built function calls.
5. Programs related to Recursion.
6. Programs involving in-built data structures like List, Tuples and Dictionaries.

7. Programs related to String processing.
8. Programs related to Files and I/O.
9. Implementation of Factoring methods.
10. Programs that require sorting, searching and selection as sub-routines.
11. Problems involving simple 2D graphics.
12. Implementation of a capstone application to unify the concepts learnt in the course.

Reading List:

1. Kenneth Lambert, Fundamentals of Python: First Programs, Cengage Learning, 2019.
2. R.G. Dromey, how to solve it by Computer, Pearson, 2008.
3. The Python Tutorial, Available at: https://docs.python.org/3/tutorial/.

PH102	Engineering Physics Lab	BSC	0-0-2	2 Credits

List of experiments (any eight of the following):

Exposure to virtual lab (any three of the following):

S. No	Name of the experiment
1	Determination of Planck’s constant using light emitting diode.
2	Determination of wavelength of monochromatic light in Newton’s ring experiment.
3	Determination of the width of narrow slit by diffraction method.
4	Determination of wavelength of He-Ne laser using diffraction by a metal scale.
5	Determination of capacitance and time constant of a capacitor using R-C circuit.
6	Determination of wavelength of mercury spectrum by normal incidence method (diffraction grating).
7	Determination of specific rotation of an optically active material-using Laurent’s half-shade polarimeter.
8	Determination of resonating frequency and bandwidth of an LCR circuit.
9	Determination of dielectric constant of various dielectric materials.
10	Studying B-H curve loop and permeability of magnetic materials.
11	Measuring spatial distribution of magnetic field between a pair of identical coils using Helmholtz coils.
12	Studying current-voltage characteristics of a photovoltaic material using solar cell.
13	Determination of numerical aperture of an optical fibre.
14	Determination of resistivities of various materials using four-probe method.

1. LCR – Series/Parallel
2. B-H Loop tracer
3. Planck's Constant
4. Numerical aperture of Optical Fiber
5. Newton's rings

Micro project:

This can be implemented in the subsequent semesters based on the facilities available. In the case of implementation, three or four experiments from the above listed eight experiments will be replaced with the project (~40 % of the experiments will be relaxed).

References:

1. *Physics Laboratory Manual*, School of Sciences (Physics), National Institute of Technology Andhra Pradesh (2020).
2. *Practical Physics (Electricity, Magnetism, and Electronics),* R. K. Shukla, A Srivastava, New age international publishers (2011).
3. *B.Sc. Practical Physics*, C. L. Arora, S. Chand & Co. Ltd. (2012).

EA101	Physical Education	MSC	0-0-3	1 Credit

Detailed Syllabus:

I. Introduction to Physical Education & EAA = Sports and Games

Meaning & Definition of Physical Education, Aims & Objectives of Physical Education, Importance of Physical Education

II. Physical Fitness & Wellness Lifestyle

Meaning & Importance of Physical Fitness, Components of Physical Fitness (Cardiovascular Endurance, Strength Endurance Muscular Endurance, Flexibility, Body Composition), Components of Motor Fitness (Agility, Balance, Power, Speed, Coordination), Development of Fitness Components

III. Training Methods in Physical Education

Circuit Training (Circuit Training), Continues Training (Endurance), Interval Training (Speed & Endurance), Fartlek Training (Speed Endurance), Weight Training (Maximum Strength), Plyometric Training (Power), Flexibility Training

IV. Test & Measurements

Measurements: Height, Weight, Age, Calculation of BMI, Motor Fitness and Physical Fitness Tests (Pre - Test & Post-Test), Cardiovascular Endurance - 9/12 Minute Run or Walk, Muscular Endurance – Sit Ups for abdominal strength, Strength Endurance – Flexed arm hang for girls / Pull ups for boys, (Speed – 50m Dash or 30mts Fly Start, Strength – Broad Jump, Vertical Jump for Lower Body, Medicine Ball Put for Shoulder Strength, Endurance - 800mts, Flexibility - Bend and Reach, Agility (Coordination)) – Shuttle Run and Box Run

V. Formal Activities

Calisthenics (free hand exercises), Dumbbells, Woops, Wands, Laziums (Rhythmic activities), Aerobic Dance and Marching

VI. Sports / Games

Following sub topics related to any one Game/Sport of choice of student out of: Athletics, Badminton, ball badminton, Kabaddi, Kho-Kho, Table Tennis, Yoga etc., Teaching & Coaching of the Game/Sport, Latest General Rules of the Game/Sport.

Specifications of Play Grounds and Related Sports Equipment

EA151	Health Education	MSC	0-0-3	1 Credit

Health Education & Personal Hygiene

Introduction & Meaning of Health Education, Definition of Health Education, Principles of Health Education, Importance of Health Education, Meaning of Personal Hygiene, Importance of Personal Hygiene, Personal cleanliness (teeth, ears, eyes, nose & throat, nails & fingers, skin, cloths, and hair).

Nutrition

Introduction of Nutrition, Balanced Diet, Daily Energy Requirements, Nutrient Balance, Nutritional Intake, Eating and Competition, Ideal Weight

First Aid & Injury Management

Introduction, Types and Principles of First Aid, Functions of First Aider, Reasons for Sports Injuries,The First Aid and Emergency Treatment in Various cases (drowning, dislocation & fractures, burns, electric shock, animal bite, snake bite, poison, etc.

Human Posture

Introduction, Meaning of Posture, types of Good Posture, causes of Poor Posture, preventive and Remedial Poor Posture, common Postural Deformities, Body Types, Advantages of Good Posture

Yoga

Introduction, Meaning & Importance of Yoga, Elements of Yoga, Introduction - Asanas, Pranayama, Meditation & Yogic Kriyas, Yoga for concentration & related Asanas (standing asanas, sitting asanas, supine and prone postures.), Relaxation Techniques for improving concentration – Yoga – nidra, Pranayama

Sports / Games

Following sub topics related to any one Game/Sport of choice of student out of: Athletics, Badminton, ball badminton, Kabaddi, Kho-Kho, Table Tennis, Yoga etc.,Teaching & Coaching of the Game/Sport., Latest General Rules of the Game/Sport, Specifications of Play Grounds and Related Sports Equipment.

ME102	**Engineering Graphics with Computer Aided Drafting**	**ESC**	**2-0-0**	**2 Credits**

Note: 50% of the Practice through manual drawing and 50% of the Practice through a Computer Aided Drafting Package.

Detailed Syllabus:

Introduction: Overview of the course, Lines Lettering and Dimensioning: Types of lines, Lettering, Dimensioning, Geometrical Construction of Polygons, Scales. Introduction to Computer Aided Drafting (CAD), DRAW tools, MODIFY tools, TEXT, DIMENSION, PROPERTIES, etc.

Orthographic Projection: Principles, of Orthographic projection, Four Systems of Orthographic Projections.

Projection of Points: Projections of points when they are situated in different quadrants.

Projections of Lines: Projections of a line parallel to one of the reference planes and inclined to the other, line inclined to both the reference planes, Traces.

Projections of Planes: Projections of a plane perpendicular to one of the reference planes and inclined to the other, Oblique planes.

Projections of Solids: Projections of solids whose axis is parallel to one of the reference planes and inclined to the other, axis inclined to both the planes.

Sections of Solids: Sectional planes, Sectional views - Prism, pyramid, cylinder and cone, true shape of the section.

Isometric Views: Isometric axis, Isometric Planes, Isometric View, Isometric projection, Isometric views - simple objects.

Reading:

1. N.D. Bhatt and V.M. Panchal, Engineering Graphics, Charotar Publishers, 2013.

2. Sham Tickoo, AutoCAD 2017 for Engineers & Designers, Dreamtech Press, 23 rd Edition, 2016.

CY101	Engineering Chemistry	BSC	3-0-0	3 Credits

Basic Organic Chemistry

Reaction intermediates: carbocations, carbanions, free radicals and carbenes. Classification of organic reactions, examples and their mechanisms: substitution, addition, elimination and rearrangement reactions. Reimer–Tiemann reaction, Kolbe-Schmidt reaction, Cannizzaro reaction. Pinacol-Pinacolone, Hofmann and Beckmann rearrangements. Diels-Alder reaction.

Spectroscopic Techniques for Chemical Analysis

Introduction of spectroscopy, Quantum aspects of electronic, vibrational and nuclear energy levels. UV-Visible spectroscopy: Principle, Instrumentation, Beer-Lambert’s law, Effect of conjugation, Woodward-Fieser empirical rules for acyclic/cyclic dienes. IR spectroscopy: Principle, Factors that affect vibrational frequencies and functional group detection. Proton NMR spectroscopy: Principle, Instrumentation, Chemical equivalency, Chemical shift and spin-spin splitting. Applications of UV-Vis, IR and proton-NMR spectroscopy in determining the structure of small organic molecules.

Coordination Chemistry

Introduction of coordination chemistry, Valence bond (VB) theory and shapes of Inorganic Compounds, Spectrochemical series, Crystal Field theory (CFT): octahedral and tetrahedral complexes, Crystal field splitting energy (CFSE); Molecular Orbital (MO) Theory: Molecular orbital diagrams for octahedral complexes (strong and weak ligand fields).

Electrochemistry

Electrodes, Electrochemical Cells, Electrochemical series and Nernst equation; Conductometry and Potentiometry; Batteries: Types of batteries, Ni-Cd and Lithium (Li)-ion batteries; Fuel Cells: Hydrogen-Oxygen, Methanol-Oxygen fuel cells; Corrosion - Theories of corrosion, Wet corrosion, Types of wet corrosion, Factors affecting the rate of corrosion, Corrosion control methods: Sacrificial anode method and Impressed current method.

Engineering Materials and Applications

Polymers: Introduction, Types of polymerization, Functionality in polymers, Number and Weight average molecular weight, Polydispersity index, Biodegradable polymers; Conductive polymers: classification, examples and applications; Organic light emitting diode (OLED): structure, principle and applications; Optical fibres: principle and Applications.

Reference books:

1. Organic Chemistry, Clayden, Greaves, Warren and Wothers, Oxford University Press, 2014.
2. Organic Spectroscopy, William Kemp, 2nd edition, Macmillan publishers, 2019.
3. Advanced Inorganic Chemistry, F. Albert Cotton, Geoffrey Wilkinson, Carlos A. Murillo and Manfred Bochmann, 6th Edition, 1988.
4. Physical Chemistry, P. Atkins and Julio de Paula, 8th Edition, Freeman & Co. 2017.
5. A Textbook of Engineering Chemistry, Shashi Chawla, 2017.
6. Polymer Science and Technology, Premamoy Ghosh, 3rd edition, McGraw-Hill, 2010.

EE101	Elements of Electrical Engineering	ESC	2-0-0	2 Credits

Detailed Syllabus

Basic Concepts

Electric Charge, Current and Electromotive force, Potential and Potential Difference; Electrical Power and Energy; Ohm's Law, Resistance, Capacitance and Inductance, Series and Parallel Connection of Resistances and Capacitances, Kirchoff's Laws and Their Applications

AC Fundamentals:

Concept of Alternating Voltage and Current, RMS and Average Values, Single Phase and Three Phase Supply; 3-ph Star-Delta connections, Alternating Voltage applied to Pure Resistance, Inductance, Capacitance and their combinations, Concept of Power and Power Factor in AC Circuit.

Measuring Instruments:

Principle and Construction of Instruments used for Measuring Current, Voltage, Power and Energy, Methods and precautions in use of these.

Electromagnetic Induction:

Concept of Magnetic Field, Magnetic Flux, Reluctance, Magneto Motive Force (MMF), Permeability; Self and Mutual Induction, Basic Electromagnetic laws, various losses in magnetic circuits;

Electrical Machines:

Elementary concepts of an electrical machine, Basic principle of a motor and a generator, Classification of Electrical machines; Principles, Construction and Working of a machine; Starters: Need, Construction and Operation; Transformer: Classification, Principles, Construction and Working of a Transformer, Applications of Transformers;

Utilization of Electricity:

Utilization concepts of Electricity for electrolysis process, Electrochemical Cells & Batteries; Application of Electricity, Energy Conversation and Efficiency

Basic Troubleshooting:

Basic Testing and faults diagnosis in electrical systems, various tools and their applications, replacement of different passive components.

Electrical Safety:

Electrical Shock and Precautions against it, Treatment of Electric Shock; Concept of Fuses and Their Classification, Selection and Application; Concept of Earthing.

Reading:

1. Edward Hughes, Electrical & Electronic Technology, Pearson, 12 th Edition, 2016.

2. Vincent Del Toro, Electrical Engineering Fundamentals, Pearson, 2 nd Edition, 2015.

3. V N Mittle and Arvind Mittal, Basic Electrical Engineering, Tata McGraw Hill, 2nd Edition, 2005.

4. E. Openshaw Taylor, Utilization of Electrical Energy, Orient Longman, 2010.

5. B.L.Theraja , Fundamentals of Electrical Engineering and Electronics volume -I, S Chand & Company 2005.

6. Ashfaq Husain, Fundamentals of Electrical Engineering, Dhanpat Rai & Sons 4 th edition, 2010.

7. H.Partab: Art & Science of Utilization of Electric Energy, Dhanpat Rai & Sons, 1998.

8. Fundamentals of Electrical Circuits by Charles k.Alexander, Mattew N.O.Saidiku, Tata McGraw Hill company.

BT101	BIOLOGY FOR ENGINEERS	ESC	2-0-0	2 Credits

Pre-requisites: None

Detailed Syllabus:

Importance of biology to engineers, Molecules of life: Water and Carbon, Evolution and origin of life, Darwins theory, Diversity of life, Chemical basis of life, Nucleic acids, Amino acids and Proteins, Carbohydrates, Lipids and Membranes.

Cell structure and function:

Prokaryotic, Eukaryotic cell and Virus, Sub cellular organelles and their functions, Regulation of cellular metabolism: Cellular respiration and Fermentation, Photosynthesis, Cell division (differences between mitosis and meiosis), Mendel's Law and Patterns of inheritance.

Gene structure and expression

Difference between prokaryotic and eukaryotic gene structure, DNA replication, Transcription, RNA processing and Translation, Control of gene expression (lac operon).

Applications of Biology in Engineering

Genetic engineering (microbe, plant and animal cells for improvement), Industrial Biotechnology (Primary and Secondary metabolites), Environmental engineering, Biopharmaceuticals, Tissue engineering, Biomaterials, Stem cell engineering, Biosensors, Bioinformatics.

Reading:

1. Quillin, Allison Scott Freeman, Kim Quillin and Lizabeth Allison, Biological Science, Pearson Education India, 2016.

2. Reinhard Renneberg, Viola Berkling and Vanya Loroch, Biotechnology for Beginners, Academic Press, 2017.

ME101	Basics of Mechanical Engineering	ESC	2-0-0	2 Credits

Detailed Syllabus:

Evolution of Mechanical Engineering: Introduction, Definition and scope of Mechanical Engineering, relation of Mechanical Engineering with other Engineering Disciplines, Revolutionary Inventions in wheels, tools, windmills, steam engine, CNC machines, Rapid Prototyping, Air-conditioning and Refrigeration, History of Mechanics, Thermodynamics and Heat Transfer, Production and Industrial Engineering, Mechatronics.

Engineering Materials: Introduction to Engineering Materials, Classification and Properties, Alloys. Composites, Micro and Nano Materials.

Manufacturing Processes: Castings - Patterns & Moulding, Metal forming, Hot Working and Cold Working Extrusion, Drawing, Rolling, Forging. Welding - Arc Welding & Gas Welding, Soldering, Brazing. Introduction to Machining processes – Lathe, Milling, Shaping, Drilling, Grinding, Introduction to NC/CNC Machines, 3D Printing.

Power Transmission: Transmission of Power, Belt Drives, Gears and Gear Trains - Simple Problems, **Fasteners and Bearings:** Fasteners - Types and Applications, Bearings - Types and Selection,

Thermodynamics: Introduction to Energy Sources - Thermodynamics - System, State, Properties, Thermodynamic Equilibrium, Process & Cycle, Zeroth law of Thermodynamics, Work & Heat, First law - Cyclic process, Change of State, Cp, Cv, Limitations of First law, Thermal Reservoirs, Heat Engine, Heat Pump/Refrigerator, Efficiency/COP, Second law, PMM2, Carnot Cycle, Entropy - T-S and P-V diagrams.

Introduction to Steam Turbines and I.C. Engines: I.C. Engines: 2-Stroke & 4-Stroke Engines, P-v Diagram; S.I. Engine, C.I. Engine, Differences.

Introduction to Heat Transfer and Refrigeration: Vapor Compression Refrigeration Cycle - Refrigerants, Desirable Properties of Refrigerants. Modes of Heat Transfer, Thermal Resistance Concept, Composite Walls & Cylinders, and Overall Heat Transfer Coefficient – problems.

Reading:

1. Dixit, U.S., Hazarika, M. and Davim, J.P, A Brief History of Mechanical Engineering, Springer, 2017.
2. M.L. Mathur, F.S. Mehta and R.P. Tiwari, R.S. Vaishwnar, Elements of Mechanical Engineering, Jain Brothers, New Delhi, 2008.
3. Praveen Kumar, Basic Mechanical Engineering, Pearson Education, India, 2013.
4. P.N. Gupta, M.P. Poonia, Elements of Mechanical Engineering, Standard Publishers, 2004.
5. C.P. Gupta, Rajendra Prakash, Engineering Heat Transfer, NemChand Brothers, New Delhi, 1994.

CE101	Engineering Mechanics	ESC	2-0-0	2 Credits

Prerequisites: None

Detailed syllabus:

Introduction - Specification of force vector, Formation of Force Vectors, Moment of Force – Cross product – Problems, Resultant of a general force system in space,

Equillibrium of force system- Degrees of freedom - Equilibrium Equations, Degree of Constraints – Free body diagrams.

Coplanar Force Systems - Introduction – Equilibrium equations – All systems, Problems

Coplanar Concurrent force system, Coplanar Parallel force system, Coplanar General force system – Point of action, Method of joints, Method of sections, Method of members.

Friction in rigid bodies- Friction – Coulombs laws of dry friction – Limiting friction, Problems on Wedge friction, Belt Friction-problems.

Centroid & Moment of Inertia - Centroid and M.I – Arial – Radius of Gyration, Parallel axis– Perpendicular axis theorem – Simple Problems.

Dynamics of Particles – Introduction to kinematics- Equations of rectilinear motion, D'Alembert's principle -Simple problems- Introduction to kinetics- Work and Energy.

Reading:

1. J.L.Meriam, L.G. Kraige, Engineering Mechanics, Statics, John Wiley &Sons,7th Edition, 2012.
2. A.K. Tayal, Engineering Mechanics, Umesh Publications, 14th Edition, 2010.
3. S S Bhavikatti and K G Rajashekarappa, Engineering Mechanics, New Age International Publication, 4th Edition.

Reference:

1. Dietmar Gross, Werner Hauger, Jorg Schroder, Wolfgang A. Wall, Nimal Rajapakse, Engineering Mechanics 1, Statics, Springer, 2nd Edition, 2013.

S. Timoshenko, D.H. Young, Pati Sukumar, J V Rao, Engineering Mechanics, Mc-Graw Hill, 5th Edition.

ME103	Workshop Practice	SD	0-1-2	2 Credits

Detailed Syllabus:

Fitting Shop: Preparation of T-Shape Work piece as per the given specifications, Preparation of U-Shape Work piece which contains: Filing, Sawing, Drilling, Grinding, and Practice marking operations.

Machine shop: Study of machine tools in particular Lathe machine (different parts, different operations, study of cutting tools), Demonstration of different operations on Lathe machine, Practice of Facing, Plane Turning, step turning, taper turning, knurling and parting and Study of Quick return mechanism of Shaping operation. Demonstration of the working of CNC and 3D Printing Machines.

Power Tools: Study of different hand operated power tools, uses and their demonstration and Practice of Power tools.

Carpentry: Study of Carpentry Tools, Equipment and different joints, Practice of Cross Half lap joint, half lap Dovetail joint and Mortise Tenon Joint.

Welding: Study of welding tools and welding equipment, Arc Welding Practice (Lap and Butt joint).

CY102	Engineering Chemistry Lab	BSC	0-0-2	2 Credits

List of experiments (any eight of the following):

Exp. No	Name of the experiment
1	Standardization of $KMnO_4$ solution
2	Determination of Iron in Haematite
3	Determination of Hardness of Water
4	Determination of available chlorine in bleaching powder and of iodine in Iodized salt
5	pH-metric titration of an acid vs a base
6	Conductometric titration of an acid vs a base
7	Potentiometric titration of Fe^{2+} against $K_2Cr_2O_7$
8	Colorimetric determination of Potassium Permanganate
9	Determination of rate of Corrosion of mild steel in acidic environment in the absence of presence of an inhibitor
10	Determination of Chlorophyll in Olive oil by using UV and Fluorescence spectroscopic techniques
11	Functional group analysis of organic compounds by using IR spectroscopic technique
12	Organic solvent evaporation by using rotary-evaporation technique

Virtual labs

1. Determination of unknown concentration of analyte by using the Beer-Lambert's law.
2. Identification of unknown components using spectroscopic techniques.
3. Nuclear magnetic resonance spectroscopy and evolution of simple ^1H NMR spectra of organic compounds
4. Study of kinetics of a reaction by using spectrophotometric methods.

Reference books:

1. Charles Corwin, Introductory Chemistry laboratory manual: Concepts and Critical Thinking, Pearson Education, 2012.
2. David Collins, Investigating Chemistry: Laboratory Manual, Freeman & Co., 1st Edition, 2006.

II Year B.Tech. (ME) Courses offered by DMEC

MM235	**MATERIALS ENGINEERING**	**ESC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: Nil

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

CO1	Describe the crystal structure and constitution of alloys.
CO2	Describe methods of determining mechanical properties and their suitability for applications.
CO3	Classify steels and cast irons and discuss their applications.
CO4	Describe the properties and applications of non-ferrous metals and alloys.
CO5	Differentiate the properties and applications of ceramics, polymers, and composites.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	3	2	1	2	-	1	-	-	-	-	1	2	1
CO2	2	3	2	1	2	-	1	-	-	-	-	1	2	1
CO3	2	3	1	1	1	-	3	-	-	-	-	1	2	1
CO4	2	3	1	1	2	-	1	-	-	-	-	1	2	1
CO5	2	3	2	1	2	-	3	-	-	-	-	1	2	1

Detailed syllabus:

Introduction to materials engineering, Classification of materials- Metals and alloys, Ceramics, Polymers and Composites

Crystal geometry and Constitution of alloys: Space lattices, Unit cells, Crystal structure, Crystal directions and planes, Crystal imperfections- Point defects, Line defects, Surface defects, Volume defects;Types of solid solutions- substitutional and interstitial; Hume-Rothery rules for solid solutions, Construction,and interpretation of binary equilibrium diagrams-isomorphous, eutectic and peritectic-type diagrams, Intermediate phases, and phase rule

Mechanical properties: Elasticity and plasticity in materials, Stress-strain curve, Resolved shear stress,Tensile properties, Hardness and hardness measurement, Impact properties, Fatigue, Creep.

Steels and Cast Irons: Iron-carbon phase diagram, Types of steels- low, medium, and high carbon steels, stainless steels, alloy steels and their applications; Heat treatment-annealing, normalizing hardening, tempering, surface hardening; Cast irons, types- white, grey, malleable, and nodular, Properties and applications of cast irons

Non-ferrous metals and alloys: Properties and applications of - Cu and its alloys, Al and its alloys, Age hardening, Ti and its alloys, Ni-based alloys.

Ceramics, Polymers and Composites: Ceramics - Crystalline ceramics, Glasses, Properties, and applications of ceramics; Polymers - Polymerization, Thermoplastics and thermosetting plastics, Properties, and applications of polymers; Composites - Concept of composites, Matrix and reinforcement, Rule of mixtures, Classification of composites, Applications of composites

Reading:

W.D. Callister (Adapted by R. Balasubramaniam), Materials Science and Engineering, 2nd ed. (2014), Wiley India, New Delhi (ISBN: 978-8126541607)

M.F. Ashby and D.R.H. Jones, Engineering Materials 1-An Introduction to Properties, Applications and Design, 4th ed. (2011), Butterworth-Heinemann Publishers, Massachusetts, USA (ISBN: 978- 0080966656)

M.F. Ashby and D.R.H. Jones, Engineering Materials 2-An Introduction to Microstructures and Processing, 4th ed. (2012), Butterworth-Heinemann Publishers, Massachusetts, USA (ISBN: 978- 0080966687)

S. H. Avner, Introduction to Physical Metallurgy, 2nd ed. (1997), McGraw-Hill Education- Publishers, New York, USA (ISBN: 978-0074630068)

V. Raghavan, Physical Metallurgy: Principles and Practice, 2nd ed. (2012) Prentice Hall of India Learning Pvt. Ltd., Delhi (ISBN: 978-8120330122)

V. Raghavan, Materials Science and Engineering: A First Course, 6th ed. (2015), Prentice Hall of India Learning Pvt. Ltd., Delhi (ISBN: 978-8120350922)

D.S. Clark and W. Varney, Physical Metallurgy for Engineers, 2nd ed. (2004) CBS Publishers and

Distributors, New Delhi (ISBN: 978-8123911786)

ME201	**ENGINEERING THERMODYNAMICS**	**PCC**	**3 - 0 - 0**	**3 Credits**

Pre-Requisites: Nil

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

CO1	Understand the concepts of continuum, system, control volume, thermodynamic properties, thermodynamic equilibrium, work, and heat.
CO2	Apply the laws of thermodynamics to analyze boilers, heat pumps, refrigerators, heat engines, compressors, and nozzles.
CO3	Evaluate the performance of steam power cycles.
CO4	Evaluate the available energy and irreversibility.
CO5	Evaluate properties of pure substances and gas mixtures.
CO6	Analyze air standard cycles applied in prime movers.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	3	3	2	1	2	1	2	-	-	2	1	1
CO2	3	3	2	3	3	1	2	-	2	-	-	2	2	2
CO3	3	2	1	2	1	1	1	-	2	-	-	2	2	2
CO4	3	3	3	-	1	1	1	-	2	-	-	2	2	2
CO5	3	3	1	3	1	1	2	-	2	-	-	2	2	2
CO6	3	3	1	3	2	1	2	-	1	-	-	2	2	2

Detailed Syllabus:

Introduction: Scope and applications of thermodynamics.

Fundamental Concepts and Definitions: Concept of continuum, microscopic and macroscopic approach, system, control volume, dimensions and units, force, weight, State, path, process, isolated system, adiabatic system, thermodynamic equilibrium, thermodynamic definition of work, different forms of work, path function, Heat, temperature and zeroth law of thermodynamics, thermometry.

First Law of Thermodynamics: First law applied to a system undergoing a cyclic process and a change of state, concept of energy, nature of energy, pure substance, two property rules. First law applied to a control volume, general energy equation, steady flow energy equation on unit mass andtime basis, application of SFEE for devices such as boiler, turbine, heat exchangers, pumps, nozzles, etc.

Second Law of Thermodynamics: Limitations of the first law, definition of a heat engine, heat pump, refrigerator, thermal efficiency, and the coefficient of performance. Kelvin-Planck and Clausius statements of the second law, their equivalence, reversible heat engine, Carnot theorems and corollaries. Reversible process, irreversible process, factors responsible for making a process irreversible. Carnot cycle, thermodynamic temperature scale. Entropy, Clausius theorem, Clausius inequality, Principle of increase of entropy, available and unavailable energy, irreversibility. Third law of thermodynamics, absolute entropy

Ideal Gas and Real Gas: Ideal gas, relation among the specific heats, internal energy, enthalpy. Analysis of isochoric, isobaric, isothermal, isentropic, isenthalpic processes, representation of the above processes on P-v, T-s planes. Determination of work, heat, entropy and enthalpy changes during the above processes, problems. Characteristic gas equations of a real gas, problems.

Pure Substance: Behavior of pure substance (steam) with reference to T-v, P-T, P-V, P-h & T-s diagrams, Triple and critical points, properties of steam, Quality of steam, its determination using throttling and separating-throttling calorimeters. Steam processes; expressions for the change in internal energy, enthalpy, work, heat, entropy in various processes, Mollier diagram, Carnot cycle, Rankine cycle, modified Rankine cycle.

Air Standard Cycles: Assumptions for air standard cycles, Analysis of Otto, Diesel, Dual combustion, Joule/Brayton cycles.

Textbooks:

1. PK Nag, Engineering Thermodynamics, TMH, New Delhi, 2013
2. GJ. Vanwylen and R.E. Sonntag, Fundamentals of Classical Thermodynamics, Wiley Eastern, NewDelhi, 2008
3. Yonus A Cengel and Michale a Boles, Thermodynamics: An Engineering Approach, McGraw Hill, 2002
4. A.Venkatesh, Basic Engineering Thermodynamics, TMH, 2012

ME202	**KINEMATICS OF MACHINERY**	**PCC**	**3 - 0- 0**	**3 Credits**

Pre-requisites: CE101: Engineering Mechanics

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

CO1	Understand the principles of kinematic pairs, chains, and their classification, DOF, inversions, equivalent chains, and planar mechanisms.
CO2	Analyze the planar mechanisms for position, velocity, and acceleration.
CO3	Synthesize planar four bar and slider crank mechanisms for specified design requirements.
CO4	Evaluate gear tooth geometry and select appropriate gears for the required applications.
CO5	Design cams and followers for specified motion profiles.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	2	-	2	-	-	-	-	-	-	2	2	2
CO2	2	3	2	3	-	-	-	-	-	-	-	2	2	2
CO3	2	2	3	3	2	-	-	-	-	-	-	2	2	2
CO4	2	2	3	2	-	-	-	-	-	-	-	2	2	2
CO5	2	2	2	-	2	-	-	-	-	-	-	2	2	2

Detailed Syllabus:

Mechanisms and Inversions: Rigid body, Mechanism and Machine, Kinematic Link, Kinematic Pair, Degrees of Freedom, Classification, Kinematic Chain, Linkage, Mechanism and Structure, Gruebler's Criterion for degrees of freedom, Mobility, Four Bar mechanism, Slider- Crank mechanism, Kinematic inversions, Double slider-crank mechanism, Inversions

Velocity and Acceleration Analysis:

a) Velocity analysis: Instantaneous center method, Kennedy's theorem, locating instantaneous centers, Relative velocity method for slider-crank mechanism, and crank and slotted lever mechanism.

b) Acceleration analysis: Klein’s construction, slider crank mechanism, Coriolis acceleration component, Crank, and slotted lever mechanism.

Kinematic Synthesis: Dimensional synthesis, function generation, path generation and motion generation, Synthesis of Four Bar linkage for specified Instantaneous conditions, Hirschhorn’s method of components, Computer Aided Kinematic Synthesis.

Gears and Gear trains: Classification, Terminology, Law of Gearing, Interferences, methods of avoiding interferences, path of contact, arc of contact. Simple gear train, compound gear train, reverted gear train, planetary/epicyclic gear train, Sun, and planet gears.

Cams: Classification and application of cams. SVAJ diagrams. Analysis of Uniform velocity, Harmonic, and cycloidal motion profiles. Graphical and analytical synthesis of planar cams with knife edge, roller, and flat faced followers.

Textbooks:

1. Amitabha Ghosh and Ashok Kumar Mallik, Theory of Mechanisms and Machines, 3rd edition, EastWest Press Pvt. Ltd., New Delhi (Reprint 2017)

2. S.S.Rattan, Theory of Machines, 3rdedition, McGraw-Hill Publications, New Delhi (2011)

3. Shigley J. E. and John Joseph Uicker, Theory of Machines and Mechanisms, 2ndedition McGraw-Hillinternational edition (2003)

4. Norton, R.L., Design of Machinery - An introduction to Synthesis and Analysis of Mechanisms andMachines, McGraw Hill International Editions, New York, Edition II, 2000.

ME203	**Production Processes and Management**	**PCC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: ME101: Basics of Mechanical Engineering,

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

CO1	Design core, core print and gating system in metal casting processes.
CO2	Develop process-maps for metal forming processes using plasticity principles
CO3	Develop joints using solid state and fusion joining, brazing and soldering techniques
CO4	Understand the evolutionary development of management thought and general principles of management.
CO5	Apply marketing concepts and tools for successful launch of a product, role of productivity in streamlining a production system.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	3	2	2	2	2	-	-	-	-	-	3	2
CO2	3	3	3	2	2	2	2	-	-	-	-	-	3	2
CO3	3	3	3	2	2	2	2	-	-	-	-	-	3	2
CO4	-	-	2	-	-	2	-	3	3	3	2	2	3	2
CO5	-	-	2	-	-	2	2	2	2	2	2	2	3	2

Detailed Syllabus:

Casting: Solidification of Alloys and its mechanism, Gating System Design and Estimation of Solidification time, Riser Design and Riser Placement, Defects and Product Design, Shell Casting, Investment Casting, Centrifugal Casting.

Metal Forming: Mechanism of plastic deformation, fundamentals of plasticity, Introduction to Force equilibrium method, State of Stress, and boundary conditions in Upsetting/forging, Rolling, Wire and tube drawing, Extrusion and Deep Drawing, Defects, Load estimation for one plane strain and one axi- symmetric bulk deformation processes.

Joining Processes: Operating principle, basic equipment, merits, and applications of Fusion and Solid-state welding processes: V-I Characteristics, Solidification Phenomenon in Welding - Microstructural Evolution - Different Zones of Weld Region and their Microstructural Evolution - Brazing and Soldering, Mechanical and Adhesive Joining, Metal and nonmetal joining.

Introduction to Software for manufacturing applications – Metal Casting, Forming and Welding.

General Management: Evolution of industry and professional management, Functions of Management, Organization Structures, Hawthorne Experiments, Motivational Theories and Leadership Styles, American and Japanese Style of Management.

Marketing Management: Marketing management process, Market segmentation, Targeting and Positioning, 4P's of marketing mix, Product Life Cycle, and marketing strategies.

Production Management: Production systems classification and characterization, Production strategies, Process management, Facility Design. Productivity and its role in the economy, Techniques for improving productivity.

Reading:

1. Amitabha Ghosh and Mallick A. K., Manufacturing Science. Affiliated East-West Press Pvt. Ltd. 2010.
2. M. P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, Third edition. Wiley India Private Limited, 2009.
3. S. Kalpakjian, Manufacturing Processes for Engineering Materials, Fifth edition. Pearson Education, 2009.
4. Sharma, P.C., "A Textbook of production Technology", S. Chand and Co. Ltd., 2014.
5. Rao, P.N. "Manufacturing Technology Foundry, Forming and Welding", 2ndEdition, TMH; 2017
6. Koontz H. and Weihrich H., “Essentials of Management”, 10 Edition, McGraw-Hill, New York,2015.
7. Kotler P.,"Marketing Management”, 15 Edition, Prentice Hall of India/Pearson, New Delhi2017.
8. Chase, Shankar, and Jacobs, “Operations and Supply Chain Management”, 14 Edition, TataMcGraw Hill, New Delhi, 2017.

ME 204	Mechanics of Materials	PCC	3-0-0	3 Credit

Pre-Requisites: CE 101: Engineering Mechanics

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

CO1	Understand statically determinate and indeterminate problems.
CO2	Determine the resistance and deformation in machine members subjected to axial, flexural and torsional loads.
CO3	Evaluate principal stresses, strains and apply the concept of failure theories for design.
CO4	Analyze thin cylinders and deflection of beam

Detailed Syllabus:

1. **Resistance and Deformation:** Concept of Resistance and deformation - Determinate and Indeterminate problems in Tension and Compression - Thermal Stresses - pure shear - young's modulus of elasticity, Poisson's ratio, Modulus of rigidity and Bulk modulus - Relation between elastic constants - Stress-strain diagrams for brittle and ductile materials - working stress - Strain energy in tension and compression - Impact loading.
2. **Thin Cylinders:** Thin Cylinders - spherical shells subjected to internal fluid pressure - Wire wound thin cylinders - Compound cylinders - Shrink fit.
3. **Shear Force and Bending Moment:** Types of supports - Types of beams - Types of loads - articulated beams - Shear Force and Bending Moment diagrams.
4. **Theory of Simple Bending:** Assumptions - Bending stresses in beams - Efficiency of various cross sections - Composite beams.
5. **Shear Stress Distribution:** Flexural shear stress distribution in different cross sections of beams.
6. **Torsion of Circular cross sections:** Theory of pure torsion - transmission of Power in Solid and Hollow circular shafts - Combined bending and torsion.
7. **Principal Stresses and Strains:** Analysis of Biaxial state of stress with and without shear - Mohr's Circle
8. **Theories of failure:** Dilation - Distortion - Maximum Principal Stress Theory - Maximum Principal Strain Theory - Maximum Shear Stress Theory - Strain Energy Theory - Distortion energy theory.
9. **Deflection of Beams:** Slope and deflection of beams - Double Integration method - Macaulay's method - strain energy method.

Reading:

1. Goodno, Barry J., and James Gere. Statics and Mechanics of Materials. Cengage Learning, 2018.
2. Shames, I. H., & Pitarresi, J. M. Introduction to Solid Mechanics, 2000.
3. Timoshenko and Gere, Mechanics of Materials, CBS Publishers, 2011.
4. E.P.Popov, Engineering Mechanics of Solids, PHI, 2009.
5. S. B. Junarkar, Mechanics of Structures, Charotar Publishers, 2010.

ME205	Fluid Mechanics and Hydraulic Machines	PCC	3-0-0	3 Credit

Pre-requisites: None

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

CO1	Apply conservation laws to fluid flow problems in engineering applications.
CO2	Analyze the pipe flow (1-D) problems and Design experimental procedure for physical model studies.
CO3	Design the working proportions of hydraulic machines.
CO4	Compute drag and lift coefficients using the theory of boundary layer flows.

UNIT 1: INTRODUCTION: Preliminaries, Types of Fluids, Concept of continuum, Properties of Manometers, pressure on plane and curved surfaces, center of pressure, fluid masses subjected to linear acceleration and uniform rotation about an axis. Importance of Fluid Mechanics in Various Engineering Fields.

UNIT 2: FLUID DYNAMICS AND DIMENSIONAL ANALYSIS: Euler's Equation of motion along a streamline, Bernoulli's equation and its applications, Momentum equation and its application to pipe flow. Dimensional Analysis, Buckingham's Pi theorem, important dimensionless numbers and their physical significance, geometric, kinematic, and dynamic similarity, model studies, Hydraulic similitude.

UNIT 3: LAMINAR AND TURBULENT FLOW: Equation of motion for laminar flow through pipes, Stokes law, transition from laminar to turbulent flow, types of turbulent flow, isotropic and homogenous turbulence, Prandtl's mixing length theory, velocity distribution in turbulent flow over smooth and rough surfaces, resistance to flow, minor losses, pipe in series and parallel, power transmission through a pipe, three reservoir problems and pipe network. Equations of motion for laminar flow of a Newtonian fluid - Viscous flow - Navier-Stoke's equations, simple exact solutions for Hydrodynamic lubrication.

UNIT 4: BOUNDARY LAYER: History of boundary layer, displacement and momentum thickness, boundary layer over a flat plate, Prandtl boundary layer equation, laminar boundary layer, application of momentum equation, turbulent boundary layer, laminar sub-layer, separation, and its control, drag and lift, drag on a sphere, 2D cylinder and airfoil, Magnus effect.

UNIT 5: HYDRAULIC MACHINES: Principle of a hydraulic machine, Turbines and their classification, impact of free jets, major and minor losses in pipes, siphon. Specific speed and unit quantities. Design aspects of Pelton turbine- its construction, power and efficiency for ideal case, characteristic curves. Design aspects of reaction turbines, construction & setting, draft tube theory, cavitation. Centrifugal pumps, various types and their important components, manometric, total head, specific speed, cavitation.

Readings

1. Introduction to Fluid Mechanics and Fluid Machines by SK Som and Biswas G and Suman Chakraborthy Published by Mc Graw Hill India, New Delhi.
2. A textbook of Hydraulics, Fluid Mechanics and Hydraulic Machines by RS Khurmi, published by S Chand, India.
3. F M White, Fluid Mechanics, Tata McGraw Hill Publication 2011.
4. Streeter V.L., Benjamin Wylie, Fluid Mechanics, McGraw Hill Book Co., New Delhi, 1999.

ME207	**Fluid Mechanics & Hydraulic Machines Laboratory**	**PCC**	**0 – 0 – 2**	**1 Credit**

Pre-requisites: None

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

CO1	Develop procedure for standardization of experiments.
CO2	Calibrate flow discharge measuring device used in pipes channels and tanks.
CO3	Determine fluid and flow properties.
CO4	Characterize laminar and turbulent flows.
CO5	Compute drag coefficients.
CO6	Test the performance of pumps and turbines.

Detailed Syllabus:

1. Calibration of Venturi – Meter, Orifice meter (discharge measuring device in pipes)
2. Calibration of Orifice and mouthpiece (discharge measuring device in Tanks).
3. Calibration of Triangular – Notch and rectangular notch (discharge measuring device in Channels).
4. Determination of Darcy Friction Factor, relative roughness for laminar and turbulent flows.
5. Application of momentum equation for determination of coefficient of impact of jets on flat and curved blades and Pelton bucket.
6. Computation of pressure drag coefficient for flow past a cylinder in a subsonic wind tunnel.
7. Performance Characteristics of single stage centrifugal pump, multi-stage centrifugal pump.
8. Performance Characteristics of Pelton turbine, Francis turbine, and Kaplan turbine.

Reading:

1. K.L.Kumar, “Engineering Fluid Mechanics” Experiments, Eurasia Publishing House, 1997.
2. Jagdish Lal, Hydraulic Machines, Metropolitan Book Co, Delhi, 1995.

ME206	**Material Testing Laboratory**	**PCC**	**0 – 0 – 2**	**1 Credit**

Prerequisites: None

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

CO1	Conduct tension test on steel, aluminum, copper, and brass
CO2	Perform compression tests on spring.
CO3	Determine elastic constants using flexural and torsion tests.
CO4	Determine hardness of metals

List of Experiments:

1. To study the stress -strain characteristics of (a) Mild Steel and (b) Tor steel by conducting tension test on U.T.M
2. To find the Brinnell's and Vicker's hardness numbers of (a) Steel (b) Brass (c) Aluminium (d) Copper by conducting hardness test.
3. To determine the Modulus of rigidity by conducting Torsion test on (a) Solid shaft (b) Hollow shaft
4. To find the Modulus of rigidity of the material of a spring by conducting Compression test.
5. To determine the young's modulus of the material by conducting deflection test on a simply supported beam.
6. To determine the Modulus of elasticity of the material by conducting deflection test on a Propped Cantilever beam.
7. To determine the Modulus of elasticity of the material by conducting deflection test on a continuous beam
8. Impact test for steel
9. Shear test on Mild Steel rods

Reference:

1. Timoshenko and Gere, Mechanics of Materials, CBS Publishers, New Delhi, 1996.

MA252	**TRANSFORMATION TECHNIQUES**	**BSC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: Nil

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

CO1	Determine Fourier series expansion of functions
CO2	Determine solutions of PDE for vibrating string and heat conduction
CO3	Evaluate real integrals using residue theorem
CO4	Transform a region to another region using conformal mapping

Course Articulation Matrix:

PO / **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	-	3	-	-	-	-	-	-	-	1	2	-
CO2	3	3	-	3	-	-	-	-	-	-	-	1	2	-
CO3	3	3	-	3	-	-	-	-	-	-	-	1	2	-
CO4	3	2	-	3	-	-	-	-	-	-	-	1	2	-

Detailed Syllabus:

Fourier series: Expansion of a function in Fourier series for a given range - Half range sine and cosine expansions

Fourier Transforms: Complex form of Fourier series - Fourier transformation and inverse transforms - sine, cosine transformations and inverse transforms - simple illustrations.

Partial Differential Equations: Solutions of Wave equation, Heat equation and Laplace’s equation by the method of separation of variables and their use in problems of vibrating string, one dimensional unsteady heat flow and two-dimensional steady state heat flow including polar form.

Complex Variables: Analytic function - Cauchy Riemann equations - Harmonic functions - Conjugate functions - complex integration - line integrals in complex plane - Cauchy’s theorem (simple proof only), Cauchy’s integral formula - Taylor’s and Laurent’s series expansions - zeros and singularities - Residues - residue theorem, evaluation of real integrals using residue theorem, Bilinear transformations, conformal mapping.

Reading:

1. R.K. Jain and S.R.K.Iyengar, Advanced Engineering Mathematics, Narosa Pub. House, 2016.
2. Erwyn Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 8th Edition, 2008.
3. B.S.Grewal, Higher Engineering Mathematics, Khanna Publications, 2017.

ME251	**DYNAMICS OF MACHINERY**	**PCC**	**2 - 1- 0**	**3 Credits**

Pre-Requisites: ME202 Kinematics of Machinery

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

CO1	Understand free and forced vibrations of single degree freedom systems.
CO2	Analyze balancing problems in rotating and reciprocating machinery.
CO3	Characterize and design flywheels.
CO4	Understand the gyroscopic effects in ships, aero planes, and road vehicles.
CO5	Analyze and design centrifugal governors.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	3	3	2	-	3	-	-	-	-	2	2	2
CO2	3	3	3	3	3	3	2	-	-	-	-	2	3	2
CO3	3	3	3	3	1	-	2	-	-	-	-	2	2	2
CO4	3	3	3	3	1	-	2	-	-	-	-	2	2	2
CO5	3	3	3	3	3	3	2	-	-	-	-	2	3	2

Detailed Syllabus:

Vibrations:

Introduction, elements of a vibrating system, free vibrations of undamped system, natural frequency, phase, degree of freedom, applications of energy methods, namely, energy method and Rayleigh's method. Studying the effect of parameters on vibrations. Excitation sources, kinds of excitations. Vibration of undamped system under harmonic excitation. Effect of frequency of excitation on the amplitude of vibrations. Magnification Factor. Vibrations under resonance.

Free vibrations of spring mass damper system, concepts of critical damping coefficient and damping factor, under damping, critical damping and over damping. Vibrations of spring mass damper system under harmonic excitation. Magnification Factor. Phase difference between excitation and motion.

Rotating unbalance, whirling of shafts, critical speed, and its practical importance in the design of shafts. Application of Dunkerley's method and Rayleigh's method for estimating the critical speed of shafts, vibration isolation. Concepts of normal mode vibrations, natural frequencies, mode shapes, nodes. Practical problems

Balancing: Balancing and its types, Rotor balancing, Single plane and two plane balancing. Unbalanced forces and couples. Static and dynamic balancing, Balancing of rotors by analytical method and graphical method. Balancing machines. Balancing of reciprocating machines: primary, secondary, and higher order unbalanced forces. Balancing of in line, V and radial engines.

Flywheels: Working principle of flywheel, Concept of dynamically equivalent link. Force analysis of single slider crank mechanism. Turning moment on the crank shaft. Turning moment diagrams. Maximum fluctuation of energy and its determination. Coefficient of fluctuation of speed. Design of flywheels. Rim type flywheel versus solid type flywheel.

Gyroscope: Principle of gyroscope, Roll, Yaw and pitch motions, Gyroscopic effect in a two-wheeler, car, ship, and aero-plane. Practical problems

Governors: Necessity of governor. Flywheels versus Governors. Different types of governors. Working principle of centrifugal governors. Concept of control force. Control force diagram. Definition of stability of governor. Condition for stability. Concept of isochronism. Sensitivity of governor. Energy of governor. Gravity controlled and spring-controlled governors. Characteristics of Watt governor, Porter governor, Proell governor, Hartnell governor, Hartung governor. Hunting of governors.

Reading:

1. Shigley, J.E., and Uicker, J.J., Theory of Machines and Mechanisms, McGraw Hill Int. Edition, New York, Edition II, 2003.
2. Norton, R.L., Design of Machinery - An introduction to Synthesis and Analysis of Mechanisms and Machines, McGraw Hill International Editions, New York, Edition II, 2000.
3. Venkatachalam, R., Mechanical Vibrations, PHI, 2014.

ME252	**TURBOMACHINES**	**PCC**	**2 - 1 - 0**	**3 Credits**

Pre-Requisites: ME201: Engineering Thermodynamics, CE236: Fluid Mechanics and Hydraulic Machines

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

CO1	Apply thermodynamic concepts to understand the working of turbo machines.
CO2	Differentiate ideal and practical gas turbine cycles.
CO3	Understand the working of gas turbine plant components and analyze their performance.
CO4	Analyze the steam power plant cycles
CO5	Design steam nozzles and steam turbines.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	2	3	1	-	-	-	-	1		1	2	2
CO2	3	3	3	2	1	2	1	-	1	-	-	1	2	3
CO3	3	2	2	2	1	-	-	-	1	-	-	1	2	3
CO4	3	3	3	2	2	2	1	-	1	-	-	1	2	3
CO5	3	2	2	2	2	-	-	-	-	-	-	1	2	2

Detailed Syllabus:

Review of Basics: Introduction to Prime Movers, Gas Turbines, Review of Basic principles - Thermodynamics, Review of Basic principles - Fluid Dynamics and Heat Transfer, Fundamentals of Rotating Machines - Energy Equation, Dimensional Analysis, Airfoil Theory.

Ideal Gas Turbine Cycles: Analysis of Ideal Gas Turbine Cycles, Simple Cycle, Regeneration Cycle, Reheat Cycle, Inter cooling Cycle.

Practical Gas Turbine Cycles: Analysis of Practical Gas Turbine Cycles, Methods of accounting for component losses, Efficiencies, change in the composition of the working fluid.

Centrifugal Compressors: Centrifugal Compressors- Principle of Operation, T-s diagram, Energy equation, velocity triangles, types of blades. Analysis of Flow, Performance Characteristics.

Axial Flow Compressors: Axial Flow Compressors - Construction, Principle of Operation, T-s diagram, Energy equation, velocity triangles. Analysis of Flow. Work done factor, Stage efficiency, Degree of reaction, Performance characteristics.

Combustion Chambers: Gas turbine combustion systems - Introduction, Geometry, Factors affecting Design & Performance, Requirements of the Combustion Chamber, Gas Turbine Combustion Emissions.

Rankine Cycle: Properties of Pure Substances, Property diagrams, Steam Power plant Layout, Rankine Cycle- Analysis, Modified Rankine Cycle, and Combined Cycle.

Steam Nozzles: Steam Nozzles- Introduction, Area- velocity relationship, Mass flow rate, Choking of Nozzles, Performance characteristics of Nozzles.

Steam Turbines: Steam Turbines - Impulse and reaction Turbines, compounding of steam turbines, multistage reaction Turbines, Reheat factor and Efficiency.

Reading:

1. Ganesan, V., Gas Turbines 3/e, Tata McGraw Hill Book Company, New Delhi, 2010.
2. Vasandani, V.P. and Kumar, D.S., Treatise on Heat Engineering, Chand and Co Publishers, New Delhi, 2011.
3. Saravanmuttoo, H.I.H., Rogers, G.F.C. and Cohen H., Gas Turbine Theory, 6/e. Pearson Prentice Education, 2008.

Learning Resources/ Readings/ Video lectures:

1. Lecture series on Turbomachinery Aerodynamics by Prof. Bhaskar Roy and Prof. A M Pradeep IIT, Bombay. For more details on NPTEL visit http://nptel.ac.in

ME 253	**GEOMETRIC MODELLING FOR CAD**	**PCC**	**3 - 0- 0**	**3 Credits**

Pre-requisites: Nil

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

CO1	Apply geometric transformations and projection methods in CAD.
CO2	Develop geometric models to represent curves.
CO3	Design surface models for engineering design.
CO4	Model engineering components using solid modelling techniques for design.
CO5	Apply geometric modelling techniques in design and analysis.

Course Articulation Matrix:

PO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	1	-	2	-	-	-	-	2	2	3
CO2	3	2	2	2	1	-	2	-	-	-	-	2	2	3
CO3	3	2	3	2	1	-	2	-	-	-	-	2	2	3
CO4	3	2	2	2	1	-	2	-	-	-	-	2	2	3
CO5	3	2	3	3	2	-	2	-	-	-	-	2	2	2

Detailed syllabus:

Introduction: Introduction to CAE, CAD. Role of CAD in Mechanical Engineering, Design process, software tools for CAD, geometric modelling.

Transformations in Geometric Modeling: Introduction, Translation, Scaling, Reflection, Rotation in 2D and 3D. Homogeneous representation of transformation, Concatenation of transformations. Computer-Aided assembly of rigid bodies, applications of transformations in design and analysis of mechanisms, etc. Implementation of the transformations using computer codes.

Projections: Projective geometry, transformation matrices for Perspective, Axonometric projections, Orthographic and Oblique projections. Implementation of the projection formulations using computer codes.

Introduction to Geometric Modeling for Design: Introduction to CAGD, CAD input devices, CAD output devices, CAD Software, Display Visualization Aids, and Requirements of Modelling.

Curves in Geometric Modeling for Design: Differential geometry of curves**,** Analytic Curves, PC curve, Ferguson's Cubic Curve, Composite Ferguson, Curve Trimming and Blending. Bezier segments, de Castegliau's algorithm, Bernstein polynomials, Bezier- subdivision, Degree elevation, Composite Bezier. B-spline basis functions, Properties of basic functions, Knot Vector generation, NURBS. Conversion of one form of curve to other. Implementation of the all the curve models using computer codes in an interactive manner.

Surfaces in Geometric Modeling for Design: Differential geometry of surfaces, parametric representation, Curvatures, Developable surfaces. Surfaces entities (planar, surface of revolution, lofted etc). Free-form surface models (Hermite, Bezier, B-spline surface). Boundary interpolating surfaces (Coon's). Implementation of the all the surface models using computer codes.

Solids in Geometric Modeling for Design: Solid entities, Boolean operations, Topological aspects, Invariants. Write-frame modeling, B-rep of Solid Modelling, CSG approach of solid modelling. Popular modeling methods in CAD software. Data Exchange Formats and CAD Applications**:**

Reading:

1. Michael E. Mortenson, Geometric Modeling, Tata McGraw Hill, 2013.
2. A. Saxena and B. Sahay, Computer-Aided Engineering Design, Anamaya Publishers, New Delhi,2005.
3. Rogers, David F., An introduction to NURBS: with historical perspective, Morgan Kaufmann Publishers, USA, 2001.
4. David F. Rogers, J. A. Adams, Mathematical Elements for Computer Graphics, TMH, 2008.

ME254	Mechanical Measurements and Metrology	PCC	3-0-0	3 Credits

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student will be able to:	
CO1	Understand the measurement terminologies and the concept of generalized measurement system.
CO2	Estimate errors and uncertainty in measurements using statistical analysis.
CO3	Classify sensors for measurement of specific parameters with required accuracy.
CO4	Select methods and devices for the measurement of machining and geometric features of components.
CO5	Design limit gauges for verifying the component tolerances.

Course Articulation Matrix:

Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2
CO1	2	3	3	3	-	2	-	-	-	-	-	-	2	2
CO2	2	3	3	2	-	2	-	-	-	-	-	-	2	2
CO3	3	3	3	2	-	3	-	-	-	-	-	-	2	2
CO4	3	2	2	2	-	-	-	-	-	-	-	-	3	-
CO5	2	2	3	-	-	-	-	-	-	2	-	2	2	2

Detailed Syllabus:

Mechanical Measurements

Basics of Measurements: Introduction, generalized measurement system, Signal flow diagram of measurement system, Inputs and their methods of correction

Presentation of experimental data: Errors in measurement, Propagation of errors, Uncertainty analysis, Regression analysis.

Pressure measurement: Different pressure measurement instruments and their comparison, Transient response of pressure transducers

Thermometry: Overview of thermometry, Thermo-electric temperature measurement, Resistance thermometry, Pyrometer, Other methods, issues in measurements.

Flow Measurement: Flow obstruction methods, Magnetic flow meters, Interferometer, LDA, Other methods.

Thermal and transport property measurement: Measurement of thermal conductivity, diffusivity, viscosity, humidity and gas composition.

Metrology:

Linear and Angular Measurements: Linear Measuring Instruments, Angle measuring instruments, Comparators, Calibration of Instruments.

Limits, Fits, Tolerances and Gauging: Interchangeability, Types of fits, Basic-Hole System, Basic-Shaft System, Types of Assemblies, Design of limit gauges, Introduction to GD&T.

Gear and Screw Thread Measurements:

Gear measurement: Introduction and Classification of gears; Forms of gear teeth; Gear tooth terminology; Methods of measuring tooth thickness, tooth profile & pitch, Gear Errors;

Screw Thread Measurement: Terminology, Forms of thread, Errors in threads, Measurement of major, minor and effective diameters (2-wire and 3-wiremethods).

Surface Roughness Measurement: Components of surface texture, Need for surface roughness measurement, Measurement of surface roughness, Roughness characterization, Roughness grades.

Reading:

1. Experimental Methods for Engineers, J P Holman, Tata McGraw Hill publications
2. Mechanical Measurements by Thomas G Beckwith, Pearson publications.
3. Measurement systems by Ernest O Doebelin, Tata McGraw Hill publications
4. I.C. Gupta, Engineering Metrology, Dhanpat Rai & Sons, 2003
5. R. K. Jain, Engineering Metrology, Khanna Publishers, 19/e, 2005.

ME255	**Industrial Engineering**	**PCC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student will be able to:	
CO1	To Design and conduct experiments, analyze, interpret data and synthesize valid conclusions
CO2	To Design a system, component, or process, and synthesize solutions to achieve desired needs
CO3	To Use the techniques, skills, and modern engineering tools necessary for engineering practice with appropriateconsiderations for public health and safety, cultural, societal, and environmental constraints.
CO4	To Function effectively within multi-disciplinary teams and understand the fundamental precepts of effective project management.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	-	-	-	-	2	-	2	-	-	3	2	2	-
CO2	3	2	3	3	3	-	-	-	-	-	-	2	3	2
CO3	3	3	-	-	3	-	-	-	-	2	-	2	3	2
CO4	3	3	3	-	-	2	-	2	3	2	3	2	2	-

INTRODUCTION: Definition of industrial engineering (I.E), development, applications, role of an industrial engineer, differences between production management and industrial engineering, quantitative tools of IE and productivity measurement. concepts of management, importance, functions of management, scientific management, Taylor’s principles, theory X and theory Y, Fayol’s principles of management.

PLANT LAYOUT: Factors governing plant location, types of production layouts, advantages and disadvantages of process layout and product layout, applications, quantitative techniques for optimal design of layouts, plant maintenance, preventive and breakdown maintenance.

OPERATIONS MANAGEMENT: Importance, types of production, applications, workstudy, method study and time study, work sampling, PMTS, micro-motion study, rating techniques, MTM, work factor system, principles of Ergonomics, flow process charts, string diagrams and Therbligs.

STATISTICAL QUALITY CONTROL: Quality control, its importance, SQC, attribute sampling inspection with single and double sampling, Control charts – X and R – charts X AND S charts and their applications, numerical examples.

TOTAL QUALITY MANAGEMENT: zero defect concept, quality circles, implementation, applications, ISO quality systems. six sigma – definition, basic concepts

RESOURCE MANAGEMENT: Concept of human resource management, personnel management and industrial relations, functions of personnel management, Job-evaluation, its importance and types, merit rating, quantitative methods, wage incentive plans, types.

VALUE ANALYSIS: Value engineering, implementation procedure, enterprise resource planning and supply chain management.

PROJECT MANAGEMENT: PERT, CPM – differences & applications, critical path, determination of floats, importance, project crashing, smoothing and numerical examples.

TEXT BOOKS:

1. Industrial Engineering and management / O.P Khanna/Khanna Publishers.
2. Industrial Engineering and Production Management/Martand Telsang/S.Chand & Company Ltd. NewDelhi

Reference Books:

1. Industrial Management / Bhattacharya DK/Vikas publishers
2. Operations Management / J.G Monks/McGrawHill Publishers.
3. Industrial Engineering and Management Science/ T. R. Banga, S. C. Sharma, N. K. Agarwal/KhannaPublishers
4. Principles of Management /Koontz O’ Donnel/McGraw Hill Publishers.
5. Statistical Quality Control /Gupta/Khanna Publishers
6. Industrial Engineering and Management /NVS Raju/Cengage Publishers

ME256	**PRODUCTION PROCESSES LABORATORY**	**PCC**	**0 - 0 - 2**	**1 Credits**

Pre-requisites: Nil

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

CO1	Fabricate weldments using gas and arc welding.
CO2	Evaluate the quality of welded joints and cast components using non-destructive testing methods.
CO3	Test the properties of molding sands.
CO4	Perform formability studies on sheet metals.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	-	-	-	-	-	-	3	3	-	2	3	3
CO2	3	2	-	-	-	-	-	-	3	3	-	2	3	3
CO3	3	2	2	2	-	-	-	-	3	3	-	2	3	3
CO4	3	2	2	2	2	2	-	-	3	3	-	2	3	3

List of Experiments:

1. Fabricate the butt joint in the given samples by using shielded metal arc welding in the given samples
2. Fabricate the butt joint in the given samples by using shielded metal submerged arc welding
3. Fabrication of circumferential butt joint in the given samples by using shielded metal arc welding
4. Fabricate butt joint in the given samples by using gas welding, SAW, TIG and MIG welding.
5. Join metal plates in the given samples using resistance spot welding
6. Join rectangular cross section plates in the given samples by flash butt welding
7. Identify welding defects by liquid penetration test in the welded sample

8. Demonstration on sweep pattern and core making in mold preparation
9. Calculate the amount of the clay content in the given molding sand
10. Find the grain fineness number of the given molding sand
11. Find the green and dry shear strength, compression strength and permeability of the given molding sand.
12. Find shatter index of the given molding sand
13. Demonstration on sand casting of at least two products.
14. Perform formability studies on sheet metals.
15. Evaluate coefficient of friction using ring compression test.

Reading:

1. Manufacturing Technology Lab manual

ME257	KINEMATICS AND DYNAMICS LABORATORY	PCC	0-0-2	1 Credits

Pre-requisites: Nil

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

CO 1	Analyze the kinematics of different mechanisms.
CO 2	Identify the essential system properties and physically visualize the concepts of frequency and time period of vibrations under free vibration
CO 3	Explain the mechanism of forced vibration to analyze the damping properties.
CO 4	Evaluate the mechanism of forced vibration to analyze the different mode shapes and critical speed of shaft.

Course Articulation Matrix:

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	-	2	-	-	2	2	-	2	3	1
CO2	3	2	2	2	-	2	-	-	2	2	-	2	3	1
CO3	3	2	3	2	-	3	-	-	3	2	-	2	3	2
CO4	3	2	2	2	-	3	-	-	3	2	-	2	3	2

Detailed Syllabus:

Cycle 1: KINEMATICS

1. To determine the link lengths of four bar chain, Single slider crank chain, and Double slider crank chain mechanisms.
2. To study the belt, rope, and chain drives
3. To identify the motion of cam and follower mechanism
4. Basic ideas concerning to clutch drive and gear and gear trains

Cycle 2: DYNAMICS

1. To estimate the acceleration due to gravity using bifilar pendulum.
2. To determine the mass moment of inertia of a given object using a Trifilar pendulum.

3. To verify the natural frequency of a bar resting on a cylindrical surface to verify the natural frequency of a semi cylindrical shell resting on a horizontal surface.
4. To find the location of the center of mass G and the moment of inertia about IG of a givenconnecting rod (Compound pendulum).
5. To determine the viscous damping coefficient of a given viscous damper
6. To estimate the damping in given vibrating system through Logarithmic decrement.
7. To determine the viscous damping coefficient of a viscous damper by observing free vibrations of Spring-Mass-Damper system.
8. To determine the coefficient of friction between two surfaces.
9. To determine the natural frequencies of the Coupled pendulum (Two-degree freedom) through (a) Normal mode vibrations (b) Beat phenomenon and then calculate the stiffness of the coupling spring
10. To determine the first and second natural frequencies of a Cantilever beam (Vibration of Continuous system)
11. To estimate the Critical speed of shafts

Reading:

1. Manufacturing Technology Lab manual

III Year B.Tech. (ME) Courses offered by DMEC

ME301	**DESIGN OF MACHINE ELEMENTS**	**PCC**	**2 - 1 - 0**	**3 Credits**

Pre-requisites: CE101: Engineering Mechanics and CE235: Mechanics of Solids

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

CO1	Identify the preferred sizes and codes, and selection of proper material for design of machine element.
CO2	Design the machine element under static and dynamic loading conditions.
CO3	Design the temporary and permanent joints required to assemble the machine elements.
CO4	Design the required spring for the given application.

Course Articulation Matrix:

PO CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	3	2	2	-	-	-	-	-	-	2	2	1
CO2	3	3	3	2	2	-	-	-	-	-	-	2	2	1
CO3	3	3	3	2	3	-	-	-	-	-	-	2	2	1
CO4	3	3	3	2	2	-	-	-	-	-	-	2	2	1

Detailed Syllabus:

Introduction: Engineering Design and classification, Basic design procedure, requirement of machine element, traditional design methods, standards and codes, selection of preferred sizes, Engineering material and its classification, Mechanical properties of engineering materials, Selection of materials, Manufacturing considerations and their selection.

Static Loading: Basics- Stresses in members subjected to different types of loads, Modes of failure, Principal stresses, Theories of failure- Rankine theory, Guests theory and Von Mises theory, Selection of failure theories to design simple machine parts.

Dynamic Loading: Stress concentration and its Importance in design, Methods to reduce stress concentration, Stress concentration factor-Theoretical and actual stress concentration factors, Notch sensitivity, Design of stress concentrated members subjected to various loads-Problems, Types of variable/Cyclic loads, Mean & amplitude Stresses, Fatigue Failure, Endurance Limit & Strength, S-N Diagram, Goodman and Soderberg criterion, Modifying factors: Size effect, surface effect, Reliability, stress concentration effects etc., Problems on design of members for finite & infinite life in members subjected to individual & combined loading, Cumulative damage in fatigue.

Design of Temporary Joints: Types of temporary joints- cotter joints, knuckle joint and fasteners, Design of cotter and knuckle joint, Forms of screw threads, Nomenclature of screw thread, Thread series and its designation, Power screws and their advantages over v-threads, Stress in screwed threads, Design of bolts based on uniform strength, Empirical relation for initial tightening, Design of screw & Nut for power screw-Problems.

Design of Permanent Joints: Types of permanent joints-Riveted and Welded Joints, Rivet heads, Terminology, Caulking and fullering, Analysis of riveted joint, Efficiency of a riveted joint, Design of boiler joints and structural joints, eccentrically loaded riveted joints, Welding process, merits and demerits of welded joint over riveted joints, weld symbols, Strength of parallel and fillet weld, Eccentrically loaded welded joints, Weld subject to bending moment and torsional moment, Problems.

Design of Springs: Types of Springs, Spring materials, terminology - Stresses in Helical coil springs of circular and non-circular cross sections, Compression-spring surge, Springs under eccentric loading and fluctuating loads, - Energy stored in springs, torsion, Belleville springs. Leaf Springs: Stresses inleaf springs, Nipping. Equalized stresses.

Reading:

1. Bhandari, V B., Design of Machine Elements, 3/e, Tata McGraw Hill Book Company, New Delhi, 2009.
2. Norton, R. L., Machine Design: An Integrated Approach, 3/e, Pearson, 2004.
3. Shigley, J.E and Mischke, C. R. Mechanical Engineering Design, 6/e, Tata McGraw Hill, 2005.
4. Paul H Black and O. E. Adams, P., Machine Design, 3/e, McGraw Hill Book Company, Inc., New York, USA., 2007.
5. Kannaiah, P., Machine Design, 2/e, Scitech Publication Pvt. Ltd., 2009.

ME302	**PRIME MOVERS AND HYBRID VEHICLES**	**PCC**	**3 - 0 - 0**	**3 Credits**

Pre-Requisites: ME201: Engineering Thermodynamics

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

CO1	Understand the importance of IC engine as a prime mover and compare its performance on the basis of thermodynamic cycles and combustion processes.
CO2	Estimate engine performance and emission parameters.
CO3	Identify harmful IC engine emissions and use viable alternate fuels in engines.
CO4	Classify electric vehicles based on batteries, electric motors, and alternate power sources.
CO5	Analyze batteries and electric motors commonly used in electric/hybrid vehicles.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	2	2	2	-	1	-	-	-	-	1	2	1
CO2	3	2	2	2	2	-	2	-	-	-	-	2	2	2
CO3	3	2	2	1	1	-	3	-	-	-	-	3	2	2
CO4	2	2	2	1	2	-	2	-	-	-	-	1	1	1
CO5	2	2	2	1	2	-	1	-	-	-	-	1	1	1

Detailed Syllabus:

POWER TRAIN FUNDAMENTALS: Automobiles and Systems-Engine Classification- S.I and C.I engine operating cycles-two and four stroke engines-scavenging-efficiencies and other performance parameters-firing order-port/valve timing diagram(demonstration)-efficiency improvements-pollution-emission standards-power transmission systems.

AIR-FUEL INDUCTIONSYSTEMS and IGNITION SYSYTEML: Engines: Fuel Tank-Fuel Filter-Fuel Pump-Air Cleaner/Filter-Carburetor-Petrol Injection Systems-TBI, MPFI and GDI-CI Engines: Injection System-

Types-Air & Solid Injection Systems-CRDI-Fuel Injectors-Super Charging and Turbo Charging-Components of Ignition Systems-Battery Ignition System-Magneto Ignition System-Electronic Ignition and Ignition Timing.

TRANSMISSION SYSYTEM: Clutch-Fluid Coupling-Construction and Function-Decoupling of Power, Speed, and Torque Characteristics of Power Transmission-Gear Box-Different Types of Gear Boxes-Determination of Gear Box Ratios for Different Vehicle Applications-Torque Converters-Automatic Transmission -CVT.

ALTERNATE POWERTRAIN TECHNOLOGY: Low Heat Rejection (LHR) Engine-Dual Fuel/Multi Fuel Engines-Cam-less Engine-VVT-Homogeneous Charge Compression Ignition (HCCI)-Homogeneous & Stratified GDI-Controlled Auto-Ignition (CAI).

Introduction to Electric Vehicles: Electric Vehicle –Need -Types –Cost and Emissions –End of life. Electric Vehicle Technology –layouts, cables, components, Controls. Batteries –overview and its types. Battery plug-in and life. Ultra-capacitor, Charging –Methods and Standards. Alternate charging sources –Wireless & Sola

Hybrid Vehicles: Hybrid Electric vehicles –Classification –Micro, Mild, Full, Plug-in, EV. Layout and Architecture –Series, Parallel and Series-Parallel Hybrid, Propulsion systems and components. Regenerative Braking, Economy, Vibration and Noise reduction. Hybrid Electric Vehicles System –Analysis and its Types, Controls.

Textbooks:

1. V. Ganesan, ‘Internal Combustion Engines’, Tata McGraw Hill Book Co, Eighth Reprint, 2010.
2. J.B. Heywood, ‘Internal Combustion Engine Fundamentals’, McGraw Hill Book Co., 2006.
3.Hybrid Electric Vehicles –Teresa Donateo, Published by ExLi4EvA, 2017
4.Electric and Hybrid Vehicles Power Sources, Models, Sustainability, Infrastructure and the Market Gianfranco Pistoia Consultant, Rome, Italy, Elsevier Publications, 2017.

Reference Books:

1. M.L. Mathur and R.P.Sharma, ‘Internal Combustion Engines’, Dhanpat Rai Publicatuions (P) Ltd., 2007.
2. Challen Bernard, ‘Diesel Engine Reference Book’, Oxford Butterworth, Heinemann, 1999.
3. T. K. Garrett,K. Newton andW. Steeds, ‘Motor Vehicle’, Butterworth, Heinemann, 13th Edition, 2000.
4.Hybrid Electric Vehicle System Modeling and Control -Wei Liu, General Motors, USA, John Wiley & Sons, Inc., 2017.
5.Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, MehrdadEhsaniYiminGao Stefano Longo Kambiz M. Ebrahimi, Taylor & Francis Group, LLC, 2018.
6.Hybrid, Electric & Fuel-Cell Vehicles Jack Erjavec, Delmar, Cengage Learning.

7.Electric and Hybrid Vehicles, Tom Denton, Taylor & Francis, 2018

ME303	COMPUTER AIDED MACHINE DRAWING	PCC	1 - 0 - 4	3 Credits

Pre-requisites: Nil

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

CO1	Develop the surfaces of different solids
CO2	Draw the machine elements including keys, couplings, and cotters, riveted, bolted, and welded joints following the conventions for engineering materials.
CO3	Construct an assembly drawing using part drawings of machine components.
CO4	Create part drawing of machine components using machine assembly

Course Articulation Matrix:

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	-	3	-	-	-	2	2	-	2	2	2
CO2	2	3	2	-	3	-	-	-	2	3	-	2	2	2
CO3	2	2	2	-	3	-	-	-	2	3	-	2	2	3
CO4	2	2	2	-	3	-	-	-	2	3	-	2	2	3

Detailed Syllabus:

Development of Surfaces: Draw the development of surfaces for Prisms, Cylinders, Pyramids and Cones.

Representation of elements of machine drawing: Engineering Materials, Surface finishes, tolerances, sectional views, Screw threads.

Component Drawings: Bolts and Nuts, locking devices, Keys and Cotter joints, Knuckle Joint, Rivetedjoints, Shaft Couplings, Bearings and Pipe joints.

Assembly Drawing Practice: Draw the assembly drawings of Stuffing Box, Eccentric, Swivel bearing, Drill jig, Tail stock, Tool post, Tool head for shaping machine, machine vice, screw jack, using the component drawings, Draw the component drawings using the assembly drawings, Machine Drawing practice using AutoCAD and CREO

Reading:

2. Bhatt, N.D., Machine Drawing, Charotar Publishing House, 2003.
3. Sidheswar, N., Kannaiah, P. and Sastry, V.V.S., Machine Drawing, Tata McGraw Hill Book Company, New Delhi, 2000.

ME304	Machine Tools and Machining Science	PCC	3-0-0	3 Credits

Pre-requisites: ME101 Basics of Mechanical Engineering, ME254: Mechanical Measurements and Metrology

Course Outcomes: At the end of the course, the student will be able to:	
CO1	Analyse the kinematic motions in a machine tool.
CO2	Estimate machining times for various machining operations
CO3	Develop interrelations among ASA, ORS and NRS systems of tool geometry.
CO4	Analyze the stresses, cutting forces, temperature, power and specific energy in metal cutting with single point cutting tool.
CO5	Select cutting fluids, tool materials and coatings to control temperature and tool wear to improve tool life and machinability
CO6	Analyze the cutting forces, temperature, power and specific energy in machining with multi point cutting tool.

Course Articulation Matrix:

Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2
CO1	2	2	-	-	-	-	-	-	-	-	-	-	3	2
CO2	2	2	-	-	-	-	-	-	-	-	-	-	3	2
CO3	3	-	-	-	-	-	-	-	-	-	-	-	2	-
CO4	3	3	2	3	-	-	2	2	-	-	-	-	3	-
CO5	3	-	-	-	-	-	2	2	-	-	-	-	3	-
CO6	3	3	2	3	-	-	2	2	-	-	-	-	3	2

Detailed Syllabus:

Machine Tools

Working and Auxiliary Motions in Machine Tools, Kinematics of Machine Tools, Machining time calculations for various machining operations, Accessories and Attachments, Thread Cutting on Lathe, Methods of indexing - Dividing head.

Finishing Processes: Grinding, Lapping, Honing & Broaching Processes.

Machining Science

Introduction: Overview of the course, Examination and Evaluation patterns, Classification of

Manufacturing Processes, History of Machining, Scope and Significance of Machining.

Geometry of Cutting Tools: Geometry of single-point turning tool: Tool-in hand system, ASA system, Significance of various angles of SPTT, Orthogonal Rake System (ORS), Normal Rake System (NRS), Conversions between ASA and ORS systems.

Mechanics of Machining: Processes: Orthogonal and Oblique cutting, Mechanics of Chip formation: Types of chips, chip-breakers, Chip reduction coefficient, shear angle, shear strain, Built-Up-Edge and its effect in metal cutting, Merchant's analysis of metal cutting process - Various forces, power and specific energy in cutting, Effect of tool geometry on cutting forces and surface finish.

Thermal aspects in machining: Sources of heat generation, Effects of temperature, Determination of cutting temperature using analytical methods, Determination of cutting temperature using experimental methods, Methods of Controlling Cutting Temperature.

Tool wear, Tool life, Machinability: Wear Mechanisms, Types of tool wear, Tool Life and Machinability.

Machining Economics: A brief treatment for single pass turning operations.

Cutting Tool Materials: Desirable Properties of tool materials, Characteristics of Cutting Tool Materials, Indexable inserts and coated tools.

Cutting Fluids: Functions, characteristics and types, Selection of cutting fluids.

Mechanics of Multipoint machining processes: Mechanics of Milling process, Mechanics of Grinding (plunge grinding and surface grinding).

Reading:

1. Kalpakjian S. and Steven R. Schmid, Manufacturing, "Engineering & Technology" Pearson,
2. 2007 Rao, P.N., Manufacturing Technology-Metal Cutting and Machine Tools, Tata McGraw Hill, New Delhi, 2000.
3. N. K. Mehta, Machine Tool Design, Tata McGraw Hill, 2012
4. P. C. Pandey and H. S. Shan, "Modern Machining Processes", TMH, 2002.
5. Amitabha Ghosh and A.K. Mallik, "Manufacturing Science", 2nd Edition East-West Press,2010
6. B L Juneja and G S Sekhon, "Fundamentals of metal cutting and machine Tools", New Age International publishers, 2001.
7. K. C. Jain and A. K. Chitale, "Production Engineering", PHI, 2014.

ME305	**IC ENGINES AND FUELS LAB**	**PCC**	**0 - 0 - 4**	**2 Credits**

Pre-Requisites: Nil

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

CO1	Conduct constant speed and emission tests on IC engines and interpret their performance.
CO2	Estimate energy distribution by conducting heat balance test on IC engines.
CO3	Determine the friction power of an IC engine by motoring, Morse and retardation tests.
CO4	Evaluate performance parameters of steam power plant.
CO5	Evaluate the performance of turbomachines.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	1	3	2	1	1	-	3	2	1	1	2	1
CO2	2	1	1	3	2	1	1	-	3	2	-	1	2	1
CO3	3	3	1	1	2	-	2	-	3	1	-	1	2	1
CO4	3	3	1	3	3	2	2	-	3	2	1	1	2	1
CO5	1	1	2	2	3	1	-	1	3	2	3	3	2	1

List of Experiments:

1. Performance test on twin cylinder air cooled diesel engine
2. Valve timing diagram
3. Retardation test on Kirloskar diesel engine
4. Performance characteristics of an Axial flow fan
5. Morse Test on Hindustan Engine
6. Performance characteristics of a single stage centrifugal blower
7. Heat balance test on Kirloskar engine
8. Performance test on single cylinder SI engine
9. Load test on Steam turbine
10. Heat Balance Test on steam condenser
11. Demonstrationof boiler

Fuels Lab List of Experiments:

1. **Abel's apparatus:** Determination of flash and fire points of a given oil sample.
2. **Redwood Viscometer No. 1:** Determination of kinematic and absolute viscosities of a given oil sample.
3. **Distillation apparatus:** Determination of distillation characteristic of a given sample of gasoline.

Reading:

1. Vasandhani V.P. and Kumar, D.S., Treatise on Heat Engineering, Chand & Co Publishers, New Delhi, 2015.
2. Ganesan, V., Gas Turbines 3rd Edition, Tata McGraw Hill Book Company, New Delhi, 2015.

ME306	**MACHINING AND METROLOGY LABORATORY**	**PCC**	**0-0-4**	**2 Credits**

Pre-requisites: ME254: Mechanical Measurements and Metrology

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

CO1	Perform different operations on a lathe.
CO2	Evaluate the effect of process parameters on shear angle, cutting forces and surface finish in machining.
CO3	Evaluate the effect of process parameters on MRR and surface finish in EDM.
CO4	Perform indexing to machine spur and helical gears on milling machine.
CO5	Evaluate internal and external taper angles, straightness and flatness of a given surface.
CO6	Evaluate dimensional and form accuracies of thread and gear profiles.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	-	-	3	-	-	-	-	2	2	-	2	3	-
CO2	2	-	-	3	-	-	-	-	2	2	-	2	3	-
CO3	2	-	-	3	-	-	-	-	2	2	-	2	3	-
CO4	2	-	-	3	-	-	-	-	2	2	-	2	3	-
CO5	2	-	-	3	-	-	-	-	2	2	-	2	3	-
CO6	2	-	-	3	-	-	-	-	2	2	-	2	3	-

List of Experiments:

Machining Cycle:

1. Turning, Taper turning, Facing, Thread cutting and chamfering on lathe (Demo: Split-half nut).
2. Eccentric turning (Demo: Different types of chucks, Belt, Chain and Geardrives).
3. Spur Gear and Helical milling (Demo: Indexing).
4. Chip reduction coefficient on shaper (Demo: 1. Quick-return mechanism, 2. Pawl and Ratchet mechanism, 3. Rack & Pinion mechanism).

5. Measurement of cutting forces and surface finish in turning (Demo: Dynamometer and its setup).

Metrology Cycle:

1. Internal and external taper measurement.
2. Thread measurement using floating carriage diameter measuring machine.
3. Straightness measurement using autocollimator.
4. Measurement of Thread and Gear profiles for their form and geometrical accuracies.
5. Demonstration Coordinate Measuring Machine for the evaluation of form errors.

Reading:

1. Kalpakjian S. and Steven R. Schmid, “Manufacturing, Engineering & Technology”, Pearson, 2007
2. I.C. Gupta, “Engineering Metrology”, DhanpatRai and Sons, 2003.

ME351	**DESIGN OF TRANSMISSION ELEMENTS**	**PCC**	**2 - 1 - 0**	**3 Credits**

Pre-requisites: ME301: Design of Machine Elements

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

CO1	Design the required size of shaft, key and coupling for the given application.
CO2	Select the appropriate gear and design the gear for the given operating conditions.
CO3	Identify the suitable bearing and design the required size of bearing.
CO4	Design the flexible elements required to transmit the desired power.
CO5	Design the suitable size of I.C. engine parts, clutch, and brake.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	3	3	1	-	2	-	-	-	-	2	3	2
CO2	3	3	3	3	1	-	2	-	-	-	-	2	3	3
CO3	3	3	3	3	1	-	2	-	-	-	-	2	3	2
CO4	3	3	3	3	1	-	2	-	-	-	-	2	3	3
CO5	3	2	3	2	2	-	2	-	-	-	-	2	2	2

Detailed Syllabus:

Design of Shafts, Keys and Couplings: Types of loading on shafts, Causes of stress concentration in shafts, Design of shafts based on strength, Design of shafts based on rigidity, Use of fatigue and stress concentration factors in Shaft Design, Practical examples, Purpose of Key, Different types of keys, Design - square and flat keys, Kennedy keys and splines, Purpose of shaft couplings, Different types of couplings, Design of rigid couplings - muff coupling, split muff coupling and flanged coupling, Design of Flexible couplings - bushed-pin flexible coupling, Oldhams coupling and Universal coupling.

Design of Gears: Classification of Gears, Law of gearing, Terminology of spur gear, Standard Systems of gear tooth, Interference and undercutting, backlash, Stresses produced in a gear tooth, Concept of uniform strength beam, Shape of uniform strength cantilever beam with point load at its free end, Lewis equation, Design of spur gear tooth based on strength, Checking the design under dynamic loading conditions and wear loading conditions, Terminology and Force analysis - Helical gears, Worm gears and Bevel gears (self-study)

Design of Friction Bearings: Conditions of proper lubrication, Mechanism of dry friction, Petroff's law, Assumptions involved in Petrof's law, Hydrodynamic lubrication, Practical examples, hydrodynamic conditions in a bearing, McKeey's equation, thick and thin film lubrications, Stability of lubrication, Bearing modulus, Heat balance in journal bearing, Design of journal bearings, Sommerfeld number, Introduction of hydrostatic bearings and magnetic bearings.

Design of Antifriction Bearings: Advantages and disadvantages over friction bearings, Different types of antifriction bearings, A qualitative comparison of performance of antifriction bearings with journal bearings, Basic static and dynamic load ratings, Equivalent radial load, Selection of bearings from manufacturers catalogue, bearings design.

Design of Flexible Elements: Belts and their construction, Flat belts versus V- belts, Open and cross belt arrangement, Ratio of belt tensions, Centrifugal tension, Effect of centrifugal tension, Design of flat belts and V-belts, Selection of wire rope and Pulleys, Introduction to Chain drive - its merits and demerits, Constructional features of a chain drive.

Design of Brakes and Clutches: Different types of brakes, Concept of self-energizing and self-locking of brakes, Practical examples, Design of band brakes, block brakes and internal expanding brakes, Necessity of a clutch in an automobile, Types of clutches, friction materials and its properties, Design of single plate, multi-plate and cone clutches based on uniform pressure and uniform wear theories.

Design of I.C. Engine parts: Design of engine parts such as Piston, Connecting rod and Crank shaft.

Reading:

1. Richard G. Budynas, J Keith Nisbett, *Shigley's Mechanical Engineering Design*, McGraw Hill, Ninth edition, 2011.
2. Robert L Norton, *Machine design an integrated approach*, Pearson Education, Second edition, 2009.
3. V B Bhandari, *Design of Machine Elements*, Tata McGraw Hill Education Private Limited, Third Edition, 2012.
4. Black and Adams, *Machine Design*, McGraw Hill and Co, New Delhi, 2002.

ME352	**HEAT AND MASS TRANSFER**	**PCC**	**2 - 1 - 0**	**3 Credits**

Pre-Requisites: ME201: Engineering Thermodynamics

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

CO1	Understand the basic modes of heat transfer.
CO2	Compute temperature distribution in steady-state and unsteady-state heat conduction.
CO3	Analyze heat transfer through extended surfaces.
CO4	Interpret forced and free convection heat transfer.
CO5	Understand the principles of radiation heat transfer and basics of mass transfer.
CO6	Design and analyze heat exchangers using LMTD and NTU methods.

Course Articulation Matrix:

PO / **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	2	2	2	-	-	-	-	-	-	-	2	1
CO2	3	2	2	2	1	-	-	-	-	-	-	-	2	3
CO3	2	3	2	2	1	-	-	-	-	-	-	-	2	3
CO4	2	3	2	2	1	-	-	-	-	-	-	-	2	2
CO5	3	2	2	1	1	-	-	-	-	-	-	-	2	2
CO6	3	2	2	2	1	-	-	-	-	-	-	-	2	3

Detailed Syllabus:

Introduction: Heat Transfer - Different Modes, Governing Laws, Applications to Heat Transfer, Numerical Problems.

General Heat Conduction Equation: Derivation of the equation in (i) Cartesian, (ii) Polar and (iii) Spherical Co-ordinate Systems.

Steady-state one-dimensional heat conduction problems in Cartesian System: Steady-state one-dimensional heat conduction problems (i) with and without heat generation and (ii) with and without varying thermal conductivity - in Cartesian system with various possible boundary conditions, Thermal Resistances in Series and in Parallel, Numerical Problems.

Steady-state radial heat conduction problems in Polar System: Steady-state one-dimensional heat conduction problems (i) with and without heat generation and (ii) with and without varying thermal conductivity - in cylindrical system with various possible boundary conditions, Thermal Resistances in Series, Numerical Problems.

Steady-state radial heat conduction problems in Spherical System: Steady-state one-dimensional heat conduction problems (i) with and without heat generation and (ii) with and without varying thermal conductivity - in Spherical system with various possible boundary conditions, Thermal Resistances in Series, Numerical Problems.

Critical Thickness of Insulation: Concept, Derivation and Numerical Problems.

Extended Surfaces or Fins: Classification, Straight Rectangular and Circular Fins, Temperature Distribution and Heat Transfer Calculations, Fin Efficiency and Effectiveness, Applications, Numerical Problems.

Transient [Unsteady-state] heat conduction: Definition, Different cases - Negligible internal thermal resistance, negligible surface resistance, comparable internal thermal and surface resistance, Lumped body, Infinite Body and Semi-infinite Body, Numerical Problems, Heisler and Grober charts: Solutions to various one-dimensional problems using the charts, Numerical problems.

Forced Convection: Boundary Layer Theory, Velocity and Thermal Boundary Layers, Prandtl number, Governing Equations - Continuity, Navier-Stokes and Energy equations, Boundary layer assumptions, Integral and Analytical solutions to above equations, turbulent flow, Various empirical solutions, Numerical Problems, Forced convection flow over cylinders and spheres, Internal flows -laminar and turbulent flow solutions, Numerical Problems.

Free convection: Laminar and Turbulent flows, Vertical Plates, Vertical Tubes and Horizontal Tubes, Empirical solutions, Numerical Problems.

Thermal Radiation: Fundamental principles - Gray, White, Opaque, Transparent and Black bodies, Spectral emissive power, Wien’s, Rayleigh-Jeans’ and Planck’s laws, Hemispherical Emissive Power, Stefan-Boltzmann law for the total emissive power of a black body, Emissivity and Kirchhoff’s Laws, View factor, View factor algebra, Net radiation exchange in a two-body enclosure, Typical examples for two-body enclosures, Radiation Shield, Numerical problems.

Heat Exchangers: Definition, Classification, LMTD method, Effectiveness - NTU method, Analytical Methods, Numerical Problems, Chart Solution for Heat Exchanger Problems: Correction Factor Charts and Effectiveness-NTU Charts, Numerical Problems.

Mass Transfer: Definition, Examples, Fick’s law of diffusion, Fick’s law as referred to ideal gases, Steady-state isothermal equi-molal counter diffusion of ideal gases, Mass diffusivity.

Reading:

1. M. NecatiOzisik, Heat Transfer - A Basic Approach, McGraw Hill, New York.

2. Incropera, F. P. and De Witt, D. P., Fundamentals of Heat and Mass Transfer, John Wiley and Sons, New York.
3. Holman, J. P., Heat Transfer, Tata McGraw Hill, New Delhi.
4. Alan J. Chapman, Heat Transfer, Macmillan, New York.

SM351	**ENGINEERING ECONOMICS AND ACCOUNTANCY**	**HSC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: Nil

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

CO1	Understand various methods of Economic Analysis and apply.
CO2	Calculate Depreciation using various methods.
CO3	Sensitize the student to Macro Economic Environment.
CO4	Analyze the financial statements with ratios for investment decisions.
CO5	Analyze costs and their role in pricing
CO6	Develop effective presentation skills

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	-	-	-	-	-	2	-	2	-	2	2	1	-	-
CO2	-	-	-	-	-	2	-	2	-	2	3	1	-	-
CO3	-	-	-	-	-	2	-	2	-	2	2	2	-	-
CO4	-	-	-	-	-	2	-	2	-	2	3	1	2	-
CO5	-	-	-	-	-	2	-	2	-	2	2	1	-	-
CO6	-	-	-	-	-	2	-	2	-	3	-	-	-	-

Detailed Syllabus:

Engineering Economics

1. Introduction to Engineering Economics, Fundamental concepts, Time value of money, Cash flow and Time Diagrams, Nominal Rate of Interest Vs effective rate of interest, choosing between alternative investment proposals, Methods of Economic analysis (Pay back, ARR, NPV, IRR and B/C ratio).
2. The Effect of borrowing on investment, Equity Vs Debt Financing, Concept of leverage, Income tax and leverage
3. Depreciation and methods of calculating depreciation (Straight line, Sum of the years digit method,

declining Balance Method, Annuity Method, Sinking Fund method).

4. National Income Accounting, Methods of Estimation, Various Concepts of National Income, Significance of National Income Estimation, and its limitations.
5. Inflation, Definition, Process and Theories of Inflation and Measures to Control,
6. Balance of payments and its impact on exchange rate.
7. New Economic Policy 1991, LPG.
8. Basics of Union Budget, various deficits such as fiscal deficit and revenue deficit.

Accountancy

9. Analysis of financial statements, income statements and balance sheet (simple ratios).
10. Cost accounting, classification of costs, cost sheet and preparation of cost sheet, breakeven analysis meaning& limitations.

Presentations/ Group Discussions on current topics.

Reading:

1. D N Dwivedi “Managerial Economics”, Vikas Publishing House Private Limited, 2010
2. Agrawal AN, “Indian Economy” Wiley Eastern Ltd, New Delhi, 2015
3. R.K Sharma and Sashi K Gupta,” Financial Management”, Kalyani Publications, 2014
4. Arora, M.N.” Cost Accounting”, Vikas Publication, 2013

Source- Internet

- Capitaline Plus Database - http://www.capitaline.com/
- Ministry of Finance - http:/finmin.nic.in/
- Database of Indian Economy - http://dbie.rbi.org.in
- Statistics of India -www.indiastat.com/ or http://mospi.nic.in/
- The Economist Magazine.

ME353	**HEAT TRANSFER LABORATORY**	**PCC**	**0 - 0 - 2**	**1 Credits**

Pre-Requisites: ME201: Engineering Thermodynamics

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

CO1	Measure important properties of fuels and oils.
CO2	Evaluate the variation of volumetric efficiency of a two-stage reciprocating air compressor as a function of receiver pressure.
CO3	Estimate heat transfer coefficient in forced convection and compare with theoretical and empirical values.
CO4	Measure heat transfer coefficient in free convection and compare with empirical values.
CO5	Estimate the efficiency and effectiveness of a pin-fin and equivalent thermal resistance of a composite slab.
CO6	Determine surface emissivity of a test plate and demonstrate working of a Heat Pipe.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	2	2	-	-	-	-	-	-	-	1	1	1
CO2	2	2	2	3	-	-	-	-	-	-	-	1	2	2
CO3	2	2	2	2	-	-	-	-	1	1	-	1	2	2
CO4	2	2	2	3	-	-	-	-	-	1	-	1	2	2
CO5	3	2	2	2	-	-	-	-	-	1	-	1	2	2
CO6	3	2	2	2	-	-	-	-	1	1	-	1	2	2

List of Experiments:

1. **Two-Stage Reciprocating Air-Compressor:** Determination of volumetric efficiency of thecompressor as a function of receiver pressure.
2. **Pin-Fin Apparatus:** Determination of temperature distribution, efficiency and effectiveness ofthe fin working in forced convection environment.
3. **Natural Convection Apparatus:** Determination of experimental and empirical values of free convection heat transfer coefficient from a Heated Vertical Cylinder.
4. **Composite Slab Apparatus:** Determination of theoretical end experimental values ofequivalent thermal resistance of a composite slab.
5. **Forced Convection Apparatus:** Determination of theoretical, experimental, and empiricalvalues of

forced convection heat transfer coefficient for flow through a circular pipe.

6. **Emissivity Apparatus:** Determination of surface emissivity of a given test plate at a given absolute temperature.
7. **Heat Pipe Demonstrator:** Demonstration of isothermal characteristic exhibited by a heat pipe in comparison to other pipes.
8. **Parallel and Counter flow Heat Exchanger:** Determination of LMTD of parallel and counterflow heat exchanger.

Reading:

1. M. NecatiOzisik, Heat Transfer - A Basic Approach, McGraw Hill, New York., 1980
2. Incropera, F. P. and De Witt, D. P., Fundamentals of Heat and Mass Transfer, John Wiley and Sons, New York, 2013
3. Holman, J. P., Heat Transfer, Tata McGraw Hill, New Delhi, 2011

ME354	MEASUREMENTS LABORATORY	PCC	0 - 0 - 2	1 Credit

Pre-Requisites: ME254: Mechanical Measurements and Metrology

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

CO1	Estimate errors and uncertainty in measurements using statistical analysis.
CO2	Calibrate measuring instruments with standards.
CO3	Identify sensors for measurement of specific parameters with required accuracy.

Course Articulation Matrix:

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	3	1	3	-	-	-	2	1	-	2	2	2
CO2	1	3	3	1	2	-	-	-	2	1	-	2	2	2
CO3	2	3	3	2	3	-	-	-	3	1	-	2	2	2

List of Experiments:

1. Calibrate strain gauge pressure sensor with Bourdon gauge.
2. Determine the mass flow rate of air using hot wire anemometer and pitot tube.
3. Demonstrate the working principle of LVDT and compare with micrometer.
4. Compare the temperature reading recorded by thermocouples, RTD, thermometers.
5. Demonstrate the working of IR thermal transducer and recording high temperatures.
6. Demonstrate torque measurement and do regression analysis.
7. Compare venturi meter, orifice meter and rotameter for flow measurement.

Reading:

1. Experimental Methods for Engineers, J P Holman, Tata McGraw Hill publications
2. Mechanical Measurements by Thomas G Beckwith, Pearson publications.
3. Measurement systems by Ernest O Doebelin, Tata McGraw Hill publications

IV Year B.Tech. (ME) Courses offered by DMEC

ME401	**MECHATRONICS**	**PCC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: EC101: Basic Electronic Engineering

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

CO1	Model and analyze mechatronic systems for an engineering application
CO2	Identify sensors, transducers, and actuators to monitor and control the behavior of process or product.
CO3	Develop PLC programs for an engineering application.
CO4	Evaluate the performance of mechatronic systems.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	3	2	2	-	-	-	2	-	-	2	2	3
CO2	3	2	2	3	2	-	-	-	2	-	2	-	2	2
CO3	3	3	2	2	3	-	2	2	2	-	-	-	2	2
CO4	3	2	2	2	3	-	2	2	2	-	-	2	2	2

Detailed Syllabus:

Introduction: Overview of the course, Examination and Evaluation patterns, History of Mechatronics, Scope and Significance of Mechatronics systems, elements of mechatronic systems, needs & benefits of mechatronics in manufacturing

Actuators: Electrical Actuators: Solenoids, relays, diodes, thyristors, triacs, BJT, FET, DC motor, Servo motor, BLDC Motor, AC Motor, stepper motors. Hydraulic & Pneumatic devices - Power supplies, valves, cylinder sequencing. Design of Hydraulic & Pneumatic circuits. Piezoelectric actuators, Shape memory alloys.

Basic System Models & Analysis: Modelling of one and two degrees of freedom Mechanical, Electrical, Fluid, and thermal systems, Block diagram representations for these systems.

Dynamic Responses of System: Transfer function, Modelling Dynamic systems, first order systems, second order systems.

Digital Electronics: Number systems, BCD codes and arithmetic, Gray codes, self-complimenting codes, Error detection and correction principles. Boolean functions using

Karnaugh map, Design of combinational circuits, Design of arithmetic circuits. Design of Code converters, Encoders, and decoders.

Signal Conditioning: Operational amplifiers, inverting amplifier, differential amplifier, Protection, comparator, filters, Multiplexer, Pulse width Modulation Counters, decoders. Data acquisition - Quantizing theory, Analog to digital conversion, digital to analog conversion.

Controllers: Classification of control systems, Feedback, closed loop and open loop systems, Continuous and discrete processes, control modes, two step Proportional, Derivative, Integral, PID controllers.

PLC Programming: PLC Principles of operation PLC sizes PLC hardware components I/O section Analog I/O section Analog I/O modules, digital I/O modules CPU Processor memory module Programming. Ladder Programming, ladder diagrams, timers, internal relays and counters, data handling, analogue input, and output. Application on real time industrial automation systems.

Case studies of Mechatronics systems: Pick and place robot, Bar code, Engine Management system, Washing machine etc.

Industry 4.0 Concepts: Introduction, IoT Techniques, Cloud computing, machine learning, Digital Twin.

Reading:

1. W. Bolton, “Mechatronics”, 5th Edition, Addison Wesley Longman Ltd, 2010
2. Devdas Shetty& Richard Kolk, “Mechatronics System Design”, 3rd Edition. PWS Publishing, 2009.
3. Alciatore David G & Hist and Michael B, “Introduction to Mechatronics and Measurement systems”,4th Edition, Tata McGraw Hill, 2006.

Video references:

1. http://video_demos.colostate.edu/mechatronics
2. http://mechatronics.me.wisc.edu

ME402	**REFRIGERATION AND AIR-CONDITIONING**	**PCC**	**3 - 0 - 0**	**3 Credits**

Pre-Requisites: ME201: Engineering Thermodynamics

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

CO1	Understand the principles and applications of refrigeration systems.
CO2	Understand vapour compression refrigeration system and identify methods for performance improvement.
CO3	Study the working principles of air, vapour absorption, thermoelectric and steam-jet refrigeration systems.
CO4	*Analyze air-conditioning processes using the principles of psychrometry.*
CO5	*Evaluate cooling and heating loads in an air-conditioning system.*

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	2	-	-	1	2	-	-	-	-	2	1	-
CO2	3	3	3	3	-	1	2	-	-	-	-	2	1	2
CO3	3	2	2	-	-	1	1	-	-	-	-	2	2	2
CO4	3	3	2	2	-	1	1	-	-	-	-	2	3	2
CO5	3	3	3	3	-	1	2	-	-	-	-	2	3	2

Detailed Syllabus:

Introduction: Introduction to Refrigeration - Basic Definition.

Air Refrigeration: Air Refrigeration Cycles - reversed Carnot cycle, Bell-Coleman cycle analysis, Air Refrigeration systems - merits and demerits, analysis.

Vapour Compression Refrigeration System (VCRS): Vapour Compression Refrigeration system - Carnot Vapour compression refrigeration cycle, Working and analysis, Limitations, Standard Vapour Compression Refrigeration system, Working and analysis, Effects of sub cooling and super heating, Multi-Pressure or Compound Vapour Compression Refrigeration Systems - Methods like Flash Gas removal, Flash inter cooling and water inter cooling.

Refrigerants: Classification, Selection of Refrigerants and Nomenclature of refrigerants, Desirable Properties of an ideal refrigerant, A discussion on Ozone layer Depletion and Global Warming.

Refrigeration systems Equipment: Refrigeration System Equipment - Compressors, Condensers, Expansion Devices and Evaporators, A brief look at other components of the system.

Vapour Absorption systems: Other types of Refrigeration systems - Vapour Absorption Refrigeration Systems, Absorbent - Refrigerant combinations, Water-Ammonia Systems, Water-Lithium Bromide System, Contrast between the two systems, Modified Version of Aqua-Ammonia System with Rectifier and Analyser Assembly.

Other systems: Brief Discussion on (i) Steam-Jet refrigeration system and (ii) Thermoelectric refrigeration system

Psychrometry: Introduction to Air-Conditioning, Basic Definition, Classification, ASHRAE Nomenclature pertaining to Air-Conditioning, Applications of Air-Conditioning, Psychrometry - Air-water vapour mixtures, Psychrometric Properties, Psychrometric or Air-Conditioning processes, Psychrometric Chart.

Air-Conditioning: Mathematical Analysis of Air-Conditioning Loads, Related Aspects, Numerical Problems, Different Air-Conditioning Systems-Central - Station Air-Conditioning System, Unitary Air- Conditioning System, Window Air-Conditioner and Packaged Air-Conditioner, Components related to Air-Conditioning Systems.

Reading:

1. Roy J. Dossat, Principles of Refrigeration, Wiley Limited
2. Arora, C. P., Refrigeration and Air-Conditioning, Tata McGraw - Hill, New Delhi.
3. Stoecker, W. F., and Jones, J. W., Refrigeration and Air-Conditioning, McGraw - Hill, New Delhi.

Data Book: Refrigerant and Psychrometric Properties - Tables and Charts [SI Units], Mathur, M. L.,and Mehta, F. S., Jain Brothers.

ME403	**COMPUTER AIDED MANUFACTURING**	**PCC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: ME101: Basics of Mechanical Engineering, ME304: Machine Tools and Machining Science

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

CO1	Develop part programs with G codes and M codes for typical components
CO2	Develop part programs with APT language
CO3	Understand the elements of an automated manufacturing environment
CO4	Apply the knowledge of AM to manufacture custom specific components

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	3	-	3	2	-	-	-	-	-	-	-	3	2
CO2	2	2	-	3	2	-	-	-	-	-	-	-	3	2
CO3	2	3	-	-	2	-	-	-	-	-	-	-	3	2
CO4	2	3	-	-	-	-	-	-	-	-	-	-	3	2

Detailed syllabus:

Introduction to Computer Aided Manufacturing (CAM): Introduction to Numerical Control (NC), Numerical control modes, NC elements, Structure of CNC machine tools, Spindle design, Drivers, Designation of axes, Drives & actuation systems, Feedback devices, CNC tooling, Automatic tool changers & Work holding devices.

CNC Control Systems: CNC Machining Centers, CNC turning centers, High-speed machine tools, machine control unit, support systems, touch-trigger probe, Adaptive Control, Introduction to FANUC, SINUMERIC controllers, DNC.

CNC Programming: Part programming fundamentals, Process planning, Axes selection, Tool selection, Steps involved in Development of Part Program, Job and Tool Set up Planning, Machining path planning.

Manual Part Programming: Manual part programming Methods, Preparatory functions, G-Codes, Miscellaneous Functions M Codes, Writing Part programs for typical components, Tool length compensation, Canned cycles, Cutter radius compensation,

Computer Aided Part Programming: Concept of CAP, APT Language, Geometry

Commands, Motion Commands like point-to-point Continuous path commands, Post processor commands, Compilation of control commands, Writing complete Part programs for typical components with APT.

Robotics: Anatomy & configuration of robot, Characteristics of robots, Grippers, Application of robots in manufacturing, Robot programming.

Group Technology: Introduction to Group technology, Part classification & coding systems: OPITZ, MICLASS coding systems, production flow analysis.

Computer Aided Process Planning (CAPP): Introduction to CAPP, Variant & Generative methodsof CAPP, advantages of CAPP.

Flexible Manufacturing System (FMS): Components of FMS, FMS equipment & control, FMS case studies.

Computer Integrated Manufacturing (CIM): Elements of CIM, CIM case studies.

Computer Aided Inspection and Quality Control: Inspection and testing Coordinate Measuring Machine, Non-Contact Inspection, and Machine Vision

Additive Manufacturing (AM): Introduction to Additive Manufacturing (AM), Need for Additive Manufacturing, Generic AM process, Distinction between AM and CNC, Classification of AM Processes, Steps in AM process, Advantages of AM, Major Applications.

Reading:

1. P.N. Rao, “CAD/CAM Principles and Applications”, 3rd Edition, Tata McGraw Hill, New Delhi, 2010.
2. Grover M. P. and Zimmers E.W. “CAD/CAM: Computer Aided Design and Manufacturing”, Prentice Hall of India, 2010.
3. YoramKoren, “Computer Control of Manufacturing Systems”, McGraw Hill Publications, 2005.
4. T.C. Chang, R.A. Wysk, H.P. Wang “Computer Aided Manufacturing”, 3rd Edition, Pearson Prentice Hall, 2006.
5. Chua Chee Kai, Leong Kah Fai, “3D Printing and Additive Manufacturing: Principles & Applications”, 4th Edition, World Scientific, 2015.

ME404	**CAE and CAM LAB**	**PCC**	**0-0-2**	**1 Credits**
Pre-requisites: Nil				
Course Outcomes: At the end of the course, the student will be able to:				

CO1	Generate code in MATLAB software to solve various engineering problems
CO2	Develop programs for simulation and visualization of mathematical models and experimental results
CO3	Solve different structural engineering elements using FEA software
CO4	Develop manual part programs for 2D-complex profiles for Fanuc and Siemens controller using CNC Simulator software.
CO5	Machine complex profiles on CNC machines using part programs

Course Articulation Matrix:

Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	2	2	-	-	3	-	-	-	2	2	-	2	2	3
CO2	2	-	-	-	2	-	-	-	2	3	-	2	3	3
CO3	2	2	-	-	3	-	-	-	2	2	-	2	2	3
CO4	3	-	3	2	-	3	-	2	-	3	-	2	2	2
CO5	3	-	3	3	-	3	-	2	-	3	-	2	2	2

Detailed Syllabus:

<u>CAE</u>

a. Computer Aided Simulation Exercises:

1. Arithmetic operations, control loops and functions
2. Solving Linear, non-linear equations, curve fitting and interpolation
3. Visualization and plotting
4. Solving engineering problems involving ODE’ s and PDE’s

b. Computer Aided Analysis Exercises:

1. Introduction to FEA software-Ansys

2. Solving truss problems using Ansys
3. Solving problems of Beams and Frames using Ansys
4. Solving problems involving triangular elements

CAM

Manual Part programming for Fanuc and Siemens Controller using CNC Simulator.

1. Simulation of turn components on CNC Simulator. (2 Exercises)
2. Turning of components on CNC Lathe. (2 Exercises)
3. Milling simulation of 2D profiles on CNC Simulator. (2 Exercises)
4. Milling of components on CNC Milling Machine. (2 Exercises)

Reading:

1. NIT Andhra Pradesh CNC Lab Manual
2. John Stenerson and Kelly Curran, “Computer Numerical Control: Operation and Programming”, PHI, New Delhi, 2009.
3. T. C. Chang, R.A.Wysk and H. P. Wang, “Computer Aided Manufacturing”, PHI, New Delhi, 2009.

ME405	**MECHATRONICS LAB**	**PCC**	**0 - 0 - 2**	**1 Credits**

Pre-requisites: Nil

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

CO1	Measure load, displacement and temperature using analogue and digital sensors.
CO2	Develop PLC programs for control of traffic lights, water level, lifts, and conveyor belts.
CO3	Develop microcontroller programming to guide a robot.
CO4	Simulate and analyze PID controllers for a physical system using MATLAB.
CO5	Develop pneumatic and hydraulic circuits using Automation studio.

Course Articulation Matrix:

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3	2	-	-	-	-	3	3	3	2	3	2
CO2	2	-	3	2	3	-	-	-	3	3	2	2	3	2
CO3	2	-	3	2	3	-	-	-	3	3	2	2	3	2
CO4	2	-	3	3	3	-	-	-	3	3	2	2	3	2
CO5	2	-	3	2	3	-	-	-	3	3	2	2	3	2

List of Experiments:

1. DYNA 1750 Transducers Kit :-
    1. Characteristics of LVDT
    2. Principle & Characteristics of Strain Gauge
    3. Characteristics of Summing Amplifier
    4. Characteristics of Reflective Opto Transducer
2. Mobile Robot with P89V51RD2microcontroller
    1. Program for Operating Buzzer Beep
    2. Program for Operating Motion control
    3. Program for Operating Direction control
    4. Program for Operating White line follower for the given arena
3. PLC PROGRAMMING
    1. Ladder programming on Logic gates, Timers &counters
    2. Ladder Programming for digital & Analogy sensors
    3. Ladder programming for Traffic Light control, Water level control and Lift control Modules

4. AUTOMATION STUDIO software
    1. Introduction to Automation studio & its control
    2. Draw & Simulate the Hydraulic circuit for series & parallel cylinders connection
    3. Draw & Simulate Meter-in, Meter-out and hydraulic press and clamping.
5. MATLAB Programming
    1. Sample programs on Matlab
    2. Simulation and analysis of PID controller using SIMULINK

Elective Courses offered by MED

Departmental Electives 1

ME361	**ADVANCED THERMODYNAMICS**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-Requisites: ME201: Engineering Thermodynamics

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

CO1	Understand Maxwell's and thermodynamic relations of gas mixtures.
CO2	Estimate thermodynamic properties of gas mixtures.
CO3	Identify the models to estimate the properties of real gases.
CO4	Analyze reactive and non-reactive gas mixtures using the concepts of statistical thermodynamics and kinetic theory of gases.
CO5	Analyze chemical reaction and combustion of gas-mixtures.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	-	-	-	-	-	-	-	-	-	-	2	-
CO2	3	3	3	3	-	-	-	-	-	-	-	-	3	2
CO3	3	3	3	-	-	-	-	-	-	-	-	-	3	3
CO4	3	3	2	2	-	-	-	-	-	-	-	-	3	3
CO5	3	3	2	3	-	-	-	-	-	-	-	-	3	2

Detailed Syllabus:

Revision of Thermodynamics: I Law of Thermodynamics, II Law of Thermodynamics, Entropy, and Availability.

Properties of Gases and Gas Mixtures: Equations of State, changes in internal energy, enthalpy and entropy for an ideal gas, Equations of state for a real gas, Virial Expansions, Law of Corresponding States, Generalized Compressibility Chart, Reduced coordinates, Other Equations of state, Dalton's Law of Partial Pressures, Internal Energy, Enthalpy and Entropy and Specific Heats of Gas Mixtures, Gibbs Function of a Mixture.

Thermodynamic Relations: Some Mathematical Theorems, Maxwell's Relations, T-ds Equations, Difference in Heat Capacities, Ratio of Heat Capacities, Energy Equation, Claussius-Clapeyron Equation, Joule-Thomson Coefficient, Evaluation of Thermodynamic Properties from Equation of State, Mixtures of Variable Composition, Conditions of Equilibrium for a Heterogeneous System, Gibbs Phase Rule, Types of Equilibrium, Conditions of Stability, Third Law of Thermodynamics.

Reactive Mixtures: Degree of Reaction, Reaction Equilibrium, Equilibrium Constant, Law of Mass Action, Thermal Ionization of Monatomic Gas, Gibbs Function Change, Fugacity and Activity, Enthalpy of Formation, Enthalpy of Combustion, Heating Values, Adiabatic Flame Temperature, Second Law Analysis of reactive Systems, Chemical Exergy, Second Law Efficiency.

Statistical Thermodynamics: Quantum Hypothesis, Quantum Principle Applied to a System of Particles, Wave-Particle Duality, De Broglie Equation, Heisenberg's Uncertainty Principle, Schrodinger's Wave Equation, Probability Function, Particle in a Box, Rigid Rotator, Harmonic Oscillator, Phase Space, Maxwell-Boltzmann Statistics, Stirling's Approximation, Bose-Einstein Statistics, Fermi-DiracStatistics, Partition Function, Entropy and Probability, Monatomic Ideal Gas, Principle of Equi-partition of Energy, Statistics of a photon gas, Electron Gas, Thermodynamic Properties.

Kinetic Theory of Gases: Molecular Model, Distribution of Molecular Velocities, Molecular Collisions with a Stationary Wall, Maxwell-Boltzmann Velocity Distribution, Average, Root-Mean Square and Most Probable Speeds, Molecules in a Certain Speed Range, Energy Distribution Function, Specific Heat of a Gas, Specific Heat of a Solid.

Transport Processes in Gases: Mean Free Path and Collision Cross-section, Distribution of Free Paths, Transport Properties.

Reading:

1. Cengel, Y.A & Boles, M.A., Thermodynamics-An Engineering Approach, 8th Ed, TMH, 2017.
2. Borgnakke, C & Sonntag, R.E., Fundamentals of Thermodynamics, 7th Ed, Wiley, 2009.
3. Nag, P.K., Basic and Applied Thermodynamics, 2nd Ed, TMH, 2017.
4. Smith, J.M. etal, Introduction to Chemical Engineering Thermodynamics, 7th Ed, TMH, 2009.
5. Mcquarrie, D.A., and Simon, J.D., Molecular Thermodynamics, Viva Books, 2010.

ME362	**GAS DYNAMICS**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-Requisites: ME201: Engineering Thermodynamics

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

CO1	Solve flow equations for quasi one-dimensional flow through variable area ducts.
CO2	Analyze the flow through constant area ducts with friction and heat transfer.
CO3	Analyze flows with normal and oblique shocks.
CO4	Solve flow problems with supersonic velocities using shock-expansion theory.
CO5	Solve linearized velocity potential equation for multi-dimensional flows.

Course Articulation Matrix:

PO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	1	-	-	-	-	-	-	-	-	2	2
CO2	3	3	3	1	-	-	-	-	-	-	-	-	2	2
CO3	3	3	2	3	-	-	-	-	-	-	-	-	2	2
CO4	3	1	2	3	-	-	-	-	-	-	-	-	2	2
CO5	3	3	3	2	-	-	-	-	-	-	-	-	2	2

Detailed Syllabus:

Introduction: Review of basic fluid dynamic and thermodynamic principles, Conservation equations forinviscid flows.

One Dimensional flow: One-dimensional wave motion, normal shock waves, Oblique shock waves,Prandtl-Meyer expansions, and applications, generalized one-dimensional flow

Nozzle Flow: Isentropic flow with area change, Flow with friction (Fanno flow), Flow with heat addition(Rayleigh flow), Method of characteristics (application to one-dimensional unsteady isentropic flow)

Supersonic Flow: Velocity Potential Equation, Numerical Techniques for Steady Supersonic Flow,Time Marching Technique for Supersonic Blunt Bodies and Nozzles

Reading:

1. Anderson, J.D Jr., Modern Compressible Flows, Tata McGraw Hill, 2012.
2. Yahya, S.M., Fundamentals of Compressible Flow, New age International Pub., 2013.

3. Zucrow, M., Gas Dynamics, Wiley India, 2013.

ME363	AUTOMOBILE ENGINEERING	DEC	3 - 0 - 0	3 Credits

Pre-Requisites:ME101: Basics of Mechanical Engineering, ME302: Prime Movers and Hybrid Vehicles

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

CO1	Understand the basic lay-out of an automobile.
CO2	Understand the operation of engine cooling, lubrication, ignition, electrical and air conditioning systems.
CO3	Understand the principles of transmission, suspension, steering and braking systems.
CO4	Understand automotive restraint system.
CO5	Study latest developments in automobiles.

Course Articulation Matrix:

PO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	-	2	3	3	-	-	-	-	-	-	-	2	2
CO2	3	3	2	3	3	-	-	-	-	-	-	-	2	2
CO3	3	2	3	2	3	-	-	-	-	-	-	-	2	2
CO4	2	3	3	3	3	-	-	-	-	-	-	-	2	2
CO5	2	3	3	3	3	-	-	-	-	-	-	-	2	2

Detailed Syllabus:

Introduction: Overview of the course, Examination and Evaluation patterns, History of Automobiles, Classification of Automobiles.

Power Plant: Classification, Engine Terminology, Types of Cycles, working principle of an IC engine, advanced classification of Engines- Multi cylinder engines, Engine balance, firing order.

Fuel System, Ignition System and Electrical system: Fuel tank, fuel filter, fuel pump, air cleaner/filter, carburetor, direct injection of petrol engines. Compression Ignition engines, Fuel Injection System- air & solid injection system, Pressure charging of engines, super charging and

turbo charging, Components of Ignition systems, battery ignition system, magneto ignition system, electronic ignition
and ignition timing. Main electrical circuits, generating & stating circuit, lighting system, indicating devices, warning lights, speedometer.

Lubricating system and cooling systems: Functions & properties of lubricants, methods of lubrication-splash type, pressure type, dry sump, and wet sump & mist lubrication. Oil filters, oil pumps, oil coolers. Characteristics of an effective cooling system, types of cooling system, radiator, thermostat, air cooling & water cooling.

Chassis: Systems in an automobile, body, chassis frame, parts of the automobile body, terminology, automobile frames, functions, constructions, sub frames, materials, and defects in frames.

Transmission system: axles, clutches, propeller shafts and differential: Types of gear boxes, automatic transmission, electronic transmission control, functions and types of front and rear axles, types and functions of the clutches, design considerations of Hotchkiss drive torque tube drive, function and parts of differential and traction control.

Steering System: functions of steering mechanism, steering gear box types, steering geometry.

Breaking and suspension system: functions and types of brakes, operation and principle of brakes, constructional and operational classification, and parking brake. Types of springs shock observers, objectives and types of suspension system, rear axle suspension, electronic control, and proactive suspension system.

Automotive air conditioning: ventilation, heating, air condition, refrigerant, compressor, andevaporator.

Wheels and tyres: Wheel quality, assembly, types of wheels, wheel rims. Construction of tyres and tyre specifications.

Automotive Restraint Systems: Seat belt, automatic seat belt tightener system, collapsible steering column, and air bags.

Reading:

1. Crouse, W.H., and Anglin, D.L., Automotive Mechanics, Tata McGraw Hill, New Delhi, 2005.
2. Heitner, J., Automotive Mechanics, Affiliated Southwest Press, New Delhi, 2000.
3. Narang, G.B., Automobile Engineering, Khanna Publishers, New Delhi, 2001.
4. Kamaraju Ramakrishna, Automobile Engineering, PHI Learning pvt. Ltd., New delhi-2012.

ME364	**ADVANCED WELDING TECHNOLOGY**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: ME203 – Production Processes and Management

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

CO1	Understand solid state welding processes such as friction stir welding and explosive welding and their applications
CO2	Apply laser beam welding processes to join metals
CO3	Analyze the welded joints fabricated through hybrid welding process
CO4	Examine weldability of cast iron, steel, and Aluminum alloys.
CO5	Analyze the welded joint fabricated through cold metal transfer welding process
CO6	Develop plastic components using ultrasonic welding process.

Course Articulation Matrix:

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	2	2	-	-	-	-	-	-	2	3
CO2	3	3	3	2	2	2	-	-	-	-	-	-	2	2
CO3	3	3	3	2	2	2	-	-	-	-	-	-	3	2
CO4	3	3	3	2	2	2	-	-	-	-	-	-	3	2
CO5	3	2	2	2	2	2	-	-	-	-	-	-	2	3
CO6	3	3	3	2	2	2	-	-	-	-	-	-	3	2

Detailed Syllabus:

Solid state welding processes: Classification of solid-state welding processes, Review of Friction stir welding, Selection of tool design, Fixture design, modification of tool and features, modeling of friction stir welding, submerged friction stir welding. Friction stir processing, Process variables, Surface modification by friction stir processing, Production of composite by friction stir processing. Adhesive bonding, vacuum brazing, Explosive welding: Process description, process parameters, joint design, advantages, and limitations applications.

Laser Beam welding (LBW): Laser Beam welding, process parameters, and Laser Beam welding of steels. Hybrid welding processes: GMAW and Laser welding, process, advantages, and Limitations, GTAW and Laser beam welding, Cold Metal Transfer welding process, advantages, limitations, and applications.

Weldability studies of cast iron and steel. Welding of dissimilar materials: Aluminum to steel, Aluminum to copper.

Ultrasonic welding, ultrasonic spot welding, line welding, continuous seam welding, welding of plastic and Induction welding of plastics, process description, application, advantages, and limitations.

Reading:

1. Nadkarni S.V., “Modern Welding Technology”, Oxford IBH Publishers, 2015.
2. Parmar R. S., “Welding Engineering and Technology”, Khanna Publishers, 2014.
3. D. L. Olson, T. A. Siewert, “Metal Handbook”, Vol 06, Welding, Brazing and Soldering, ASM International Hand book Metals Park, Ohio USA, 2015.

ME365	**TOOL DESIGN and ENGINEERING**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: ME203: Production Process and Management, ME301: Design of Machine Elements,ME304: Machine Tools and Machining Science

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

CO1	Design Locating and Clamping systems for the given component based on geometrical and dimensional features.
CO2	Select and design progressive, compound or combination dies for producing a given component.
CO3	Design single point and multipoint cutting tools for conventional and CNC Machining.
CO4	Design jigs and fixtures for conventional and NC machining.

Course Articulation Matrix:

PO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	-	2	-	-	-	-	-	-	3	2
CO2	3	2	-	-	-	2	-	-	-	-	-	-	3	2
CO3	3	-	-	-	-	2	-	-	-	-	-	-	3	2
CO4	3	2	-	-	2	2	-	-	-	-	-	-	3	2

Detailed Syllabus:

Introduction: Tool design - An overview, Introduction to Jigs and fixtures.

Work holding devices: Basic principle of six-point location, Locating methods and devices,Principle of clamping and Types of clamps.

Design of jigs: Type of Drill bushes, Classification of drill jigs, Design of drill jigs.

Design of fixtures: Design of milling fixtures, Design of turning fixtures.

Introduction of press tool design: Introduction to Die cutting operations, Introduction to press andclassifications, die set assembly with components, Introduction to Centre of pressure, Examples of center of pressure, Design of piercing die, Design of blanking die, Progressive, Compound and Combination dies.

Design of cutting tools: Introduction to cutting tools, Design of single point tool, Design of drill bit, Design of milling cutter.

Brief introduction of NC machines work holding devices: Tool design for NC machines- An introduction, Fixture design for NC Machine, cutting tools for NC Machine, Tool holding methods for NC Machine, ATC and APC for NC Machine, Tool presetting for NC Machine.

Reading:

1. F. W. Wilson, "Fundamentals of Tool Design”, ASME, PHI, New Delhi,2010
2. Donaldson C, G. H. Lecain and V. C. Goold, “Tool Design”, TMH, New Delhi,2010
3. Prakash Joshi, “Jigs and Fixtures Design Manual”, 2nd Edition, McGraw-Hill Professional, 2002.
4. K. Venkataraman, “Design of Jigs, Fixtures and Press Tools”, 1st Edition, Wiley; Athena Academic, 2015.

ME366	**NON-DESTRUCTIVE TESTING**	**DEC**	**3- 0 - 0**	**3 Credits**

Pre-requisites: NIL

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

CO1	Understand general principles of NDT techniques
CO2	Conduct NDT techniques and interpret the results
CO3	Select appropriate NDT techniques in practical applications
CO4	Apply codes and standards used in NDT techniques

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	3	-	-	-	-	-	-	-	-	-	3	3
CO2	3	2	3	-	-	-	-	-	-	-	-	-	3	2
CO3	3	3	3	-	-	-	-	-	-	-	-	-	2	2
CO4	3	2	3	-	-	-	-	-	-	-	-	-	2	2

Detailed syllabus:

Introduction to NDT, Liquid Penetrant Test: Physical Principles, Procedure for penetrant testing, Penetrant testing materials, Penetrant testing methods, sensitivity, Applications and limitations, typical examples.

Ultrasonic testing: Basic properties of sound beam, Ultrasonic transducers, Inspection methods, Techniques for normal beam inspection, Techniques for angle beam inspection, Flaw characterization techniques, Applications of ultrasonic testing, Advantages, and limitations.

Thermography: Basic principle, Detectors and equipment, techniques, applications.

Radiography: Basic principle, Electromagnetic radiation sources, radiographic imaging, Inspection techniques, applications, limitations, typical examples.

Eddy current test: Principles, instrumentation for ECT, techniques, sensitivity, advanced eddy currenttest methods, applications, limitations.

Acoustic Emission: Principle of AET, Technique, instrumentation, sensitivity, applications, Acousticemission technique for leak detection.

Magnetic Particle Inspection: Principle of MPT, Procedure used for testing a component, sensitivity, limitations.

Practical NDT: Principles, procedures, applications, limitations, codes, and standards widely used innon-destructive testing (NDT) techniques. Reliability in NDT.

Reading:

1. Peter J Shull, “Nondestructive Evaluation: Theory, Techniques and Applications”, Marcel Dekkar, 2002.
2. P. McIntire (Ed.), “Non-Destructive Testing Handbook”, Vol. 4, American Society for Non Destructive Testing, 2010
3. ASM Metals Handbook, “Non-Destructive Testing and Quality Control”, Vol. 17, ASM, 1989.
4. Baldev Raj, M. Thavasimuthu, T. Jaya kumar, “Practical Non-Destructive Testing”, 3rd Edition, Narosa Publishing House, 2009.

ME367	**MECHANICAL VIBRATIONS**	**DEC**	**3-0-0**	**3 Credits**

Pre-requisites: CE101: Engineering Mechanics.

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

CO1	Develop schematic models for physical systems and formulate governing equations of motion.
CO2	Analyze rotating and reciprocating systems and compute critical speeds.
CO3	Analyze and design machine supporting structures, vibration isolators and absorbers.
CO4	Calculate free and forced vibration responses of multi degree freedom systems using modal analysis.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	3	1	1	-	-	-	-	-	-	2	2	2
CO2	3	3	2	2	2	-	-	-	-	-	-	2	2	2
CO3	3	3	2	3	2	-	-	-	-	-	-	3	2	2
CO4	3	3	2	2	3	-	-	-	-	-	-	3	2	2

Detailed Syllabus:

Introduction: Causes and effects of vibration, Classification of vibrating system, Discrete and continuous systems, degrees of freedom, Identification of variables and Parameters, Linear and nonlinear systems, linearization of nonlinear systems, Physical models, Schematic models and Mathematical models.

SDF systems: Formulation of equation of motion: Newton -Euler method, De Alembert's method, Energy method, Undamped Free vibration response and Damped Free vibration response, Case studies on formulation and response calculation.

Forced vibration response: Response to harmonic excitations, solution of differential equation of motion, Vector approach, Complex frequency response, Magnification factor Resonance, Rotating/reciprocating unbalances, Force Transmissibility, Motion Transmissibility, Vehicular suspension, Vibration measuring instruments, Case studies on forced vibration.

Two degree of freedom systems: Introduction, Formulation of equation of motion: Equilibrium method, Lagrangian method, Case studies on formulation of equations of motion.
Free vibration response, Eigen values and Eigen vectors, Normal modes and mode superposition, coordinate coupling, decoupling of equations of motion, Natural coordinates, Response to initial conditions, free vibration response case studies, Forced vibration response, undamped vibration absorbers, Case studies on undamped vibration absorbers.

Multi degree of freedom systems: Introduction, Formulation of equations of motion, Free vibration response, Natural modes and mode shapes, orthogonally of model vectors, normalization of model vectors, decoupling of modes, model analysis, mode superposition technique, Free vibration response through model analysis, Forced vibration analysis through model analysis, Model damping, Rayleigh’s damping, Introduction to experimental model analysis.

Continuous systems: Introduction to continuous systems, Exact and approximate solutions, free vibrations of strings, bars, and beams.

Reading:

1. L. Meirovich, Elements of Vibration analysis, 2nd Ed. Tata Mc-Grawhill, 2007
2. Singiresu S Rao, Mechanical Vibrations. 4th Ed., Pearson education, 2011
3. W.T., Thompson, Theory of Vibration, CBS Publishers
4. Clarence W. de Silva, Vibration: Fundamentals and Practice, CRC Press LLC, 2000

ME 368	**DESIGN OPTIMIZATION METHODS**	**DEC**	**3-0-0**	**3 Credits**

Pre-requisites: Nil

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

CO1	Formulate a design task as an optimization problem
CO2	Solve unconstrained optimization problems
CO3	Formulate constrained optimization problem and solve using corresponding methods
CO4	Solution of discontinuous optimization problems using special methods
CO5	Solve the nonlinear optimization problems with evolutionary methods

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	3	3	3	-	-	1	-	2	-	1	3	3
CO2	3	3	3	3	3	-	-	1	-	2	-	1	3	3
CO3	3	3	3	3	3	-	-	1	-	2	-	1	3	3
CO4	3	3	3	3	3	-	-	1	-	2	-	1	3	3

Detailed syllabus:

Introduction to optimization in design: Problem formulation, Optimization problems in Mechanical Engineering, Classification of methods for optimization

Single-variable Optimization: Optimal criteria, Derivative-free methods (bracketing, region elimination), Derivative based methods, root-finding methods.

Multiple-variable Optimization: Optimal criteria, direct search methods (Box's, Simplex, Hooke-Jeeves, Conjugate methods), Gradient-based methods (Steepest Descent, Newton's, Marquardt's, DFP method). Formulation and Case studies.

Constrained Optimization: KKT conditions, Penalty method, and Sensitivity analysis, direct search methods for constrained optimization, quadratic programming, GRG method, Formulation and Case studies.

Specialized algorithms: Integer programming (Penalty function and branch-and-bound method), Geometric programming.

Evolutionary Optimization algorithm: Genetic algorithms, simulated annealing, Anti-colony optimization, Particle swarm optimization.

Multi-objective Optimization: Terminology and concepts, the concepts of Pareto optimality and Pareto optimal set, formulation of multi-objective optimization problem, NSGA.

Case studies and Computer Implementation: Representative case studies for important methods and development of computer code for the same to solve problems.

Readings:

1. Jasbir Arora, Introduction to Optimum Design, Academic Press, 2004
2. Kalyanmoy Deb, Optimization for Engineering Design: Algorithms and Examples, PHI, 2004.
3. Kalyanmoy Deb, Multi-Objective Optimization using Evolutionary Algorithms, Wiley, 2001.

ME369	**FINITE ELEMENT METHOD**	**DEC**	**3-0-0**	**3 Credits**

Pre-Requisites: Nil

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

CO1	Apply finite element method to solve problems in solid mechanics and Heat transfer.
CO2	Formulate and solve problems in one dimensional structure including trusses, beams, and frames.
CO3	Formulate FE characteristic equations for two dimensional elements and analyses plain stress, plain strain, and axi-symmetric and plate bending problems.
CO4	Implement and solve the finite element formulations using MATLAB.

Course Articulation Matrix:

PO / **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	2	-	-	3	-	-	-	-	-	-	2	2	2
CO2	3	3	2	2	3	-	-	-	-	-	-	2	2	2
CO3	3	3	2	2	3	-	-	-	-	-	-	2	2	2
CO4	2	2	-	-	3	-	-	-	-	-	-	2	2	3

Detailed Syllabus:

Introduction: Overview of the course, examination and evaluation patterns, history, and basic conceptof finite element method and direct FEM.

Fundamental concepts: Calculus of variation and solving differential equations, Ritz method, Galerkinmethod, Least squares, collocation and subdomain methods, Case studies for Ritz and Galerkin methods, Ritz FEM formulation, Galerkin FEM formulation.

One-Dimensional Problems: Finite element formulation for 1-D problems, elimination method, penaltymethod, computer implementation and case studies.

Trusses: Introduction, fem formulation, plane trusses, three dimensional trusses, frames and casestudies.

Two-Dimensional Problems: Finite element formulation for 2-D problems, constant strain triangle,various elements, iso parametric, sub parametric and super parametric elements, interpolation functions, computer implementation and case studies.

Numerical Integration and 2-D problems of Elasticity: Introduction to numerical integration, two dimensional integrals, plane stress, plane strain, axisymmetric, plate bending problems.

Thermal Applications: Two - dimensional heat conduction analysis, formulation of functional, elementmatrices and case studies.

Fluid Mechanics Applications: Stream function formulation, velocity potential formulation andtorsional analysis of a prismatic bar.

Three Dimensional Problems: Finite element formulation for 3-D problems, mesh preparation,hexahedral elements, shell elements and case studies.

Reading:

1. Seshu P., Textbook of Finite Element Analysis, PHI, 2009
2. Reddy, J.N., Finite Element Method in Engineering, Tata McGraw Hill, 2007.
3. Zeincowicz, The Finite Element Method for Solid and Structural Mechanics, 4th Edition, Elsevier 2007.

ME370	**MANAGEMENT SCIENCE AND PRODUCTIVITY**	**PCC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: Nil

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

CO1	Understand the evolutionary development of management thought and general principles of management.
CO2	Apply marketing concepts and tools for successful launch of a product.
CO3	Understand the role of productivity in streamlining a production system.
CO4	Apply the inventory management tools in managing inventory.
CO5	Apply quality engineering tools to the design of products and process controls.
CO6	Apply project management tools to manage projects.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	-	-	2	-	-	2	-	3	3	3	2	2	3	2
CO2	-	-	2	-	-	2	2	2	2	2	2	2	3	2
CO3	2	2	2	2	-	2	-	2	2	-	2	2	3	3
CO4	2	2	-	-	-	-	-	-	-	-	-	-	2	2
CO5	2	3	2	3	-	-	-	2	2	-	-	2	3	3
CO6	2	-	2	-	-	-	2	2	2	2	3	-	2	3

Detailed Syllabus:

General Management: Introduction of the course, Evolution of industry and professional management, Functions of Management, Organization Structures, Hawthorne Experiments, Motivational Theories and Leadership Styles, American and Japanese Style of Management.
Marketing Management: Marketing management process, Market segmentation, Targeting and Positioning, 4 P's of marketing mix, Product Life Cycle and marketing strategies.
Production Management: Production systems classification and characterization, Production strategies, Process management, Facility Design.

Productivity and Work study: Productivity and its role in the economy, Techniques for improving productivity, Method study, Principles of motion economy, Stopwatch time study, Work sampling.

Quality Management: Dimensions of quality, Process control charts, Acceptance sampling, Taguchi'stotal quality control, Quality function deployment, Introduction to TQM.

Inventory Management: Purpose of inventories, Inventory costs, ABC classification, Economic OrderQuantity (EOQ), P and Q systems of inventory control.

Project Management: Project activities, Network diagrams, Critical path method, PERT, Project Feasibility studies.

Reading:

1. Koontz H. and Weihrich H., "Essentials of Management", 10th Edition, McGraw-Hill, New York,2015.
2. Kotler P, "Marketing Management", 15th Edition, Prentice Hall of India/Pearson, New Delhi2017.
3. Chase, Shankar, and Jacobs, "Operations and Supply Chain Management", 14th Edition, Tata McGraw Hill, New Delhi, 2017.

Departmental Electives 2

ME371	**COMPUTATIONAL FLUID DYNAMICS**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-Requisites: CE236: Fluid Mechanics and Hydraulic Machines

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

CO1	Explain the differential equations for flow phenomena and numerical methods for their solution.
CO2	Critically analyze different mathematical models and computational methods for fluid flow and heat transfer simulations.
CO3	Solve computational problems related to fluid flows and heat transfer.
CO4	Analyze the accuracy of a numerical solution by comparison to known solutions of simple test problems and by mesh refinement studies.
CO5	Evaluate forces in both internal and external flows.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	-	-	-	-	-	-	-	-	-	2	2	-
CO2	3	3	3	3	3	-	-	-	-	-	-	2	3	2
CO3	3	3	3	-	3	-	-	-	-	-	-	2	3	3
CO4	3	3	2	2	3	-	-	-	-	-	-	2	3	3
CO5	3	3	2	3	3	-	-	-	-	-	-	2	3	2

Detailed Syllabus:

Introduction: History and Philosophy of computational fluid dynamics, CFD as a design and research tool, Applications of CFD in engineering, Programming fundamentals, MATLAB programming, Numerical Methods

Governing equations of fluid dynamics: Models of the flow, the substantial derivative, Physical meaning of the divergence of velocity, The continuity equation, The momentum equation, The energy equation, Navier-Stokes equations for viscous flow, Euler equations for inviscid flow, Physical boundary conditions, Forms of the governing equations suited for CFD, Conservation form of the equations, shock fitting and shock capturing, Time marching and space marching.

Mathematical behavior of partial differential equations: Classification of quasi-linear partial differential equations, Methods of determining the classification, General behavior of Hyperbolic, Parabolic and Elliptic equations.

Basic aspects of discretization: Introduction to finite differences, Finite difference equations using Taylor series expansion and polynomials, Explicit and implicit approaches, Uniform, and unequally spaced grid points.

Grids with appropriate transformation: General transformation of the equations, Metrics and Jacobians, the transformed governing equations of the CFD, Boundary fitted coordinate systems, Algebraic and elliptic grid generation techniques, Adaptive grids.

Parabolic partial differential equations: Finite difference formulations, Explicit methods - FTCS,Richardson and DuFort-Frankel methods, Implicit methods - Lasonen, Crank-Nicolson and Beta formulation methods, Approximate factorization, Fractional step methods, Consistency analysis, Linearization.

Stability analysis: Discrete Perturbation Stability analysis, von Neumann Stability analysis, Error analysis, Modified equations, Artificial dissipation, and dispersion.

Elliptic equations: Finite difference formulation, solution algorithms: Jacobi-iteration method, Gauss- Siedel iteration method, point- and line-successive over-relaxation methods, alternative direction implicit methods.

Hyperbolic equations: Explicit and implicit finite difference formulations, splitting methods, multi-step methods, applications to linear and nonlinear problems, linear damping, flux corrected transport, monotone and total variation diminishing schemes, TVD formulations, entropy condition, first-order and second-order TVD schemes.

Scalar representation of Navier-Stokes equations: Equations of fluid motion, numerical algorithms: FTCS explicit, FTBCS explicit, Dufort-Frankel explicit, McCormack explicit and implicit, BTCS and BTBCS implicit algorithms, applications.

Grid generation: Algebraic Grid Generation, Elliptic Grid Generation, Hyperbolic Grid Generation, Parabolic Grid Generation

Finite volume method for unstructured grids: Advantages, Cell Centered and Nodal point Approaches, Solution of Generic Equation with tetrahedral Elements, 2-D Heat conduction with Triangular Elements.

Reading:

1. Anderson, J.D. (Jr), Computational Fluid Dynamics, McGraw-Hill Book Company, 1995.
2. Hoffman, K.A., and Chiang, S.T., Computational Fluid Dynamics, Vol. I, II and III, Engineering Education System, Kansas, USA, 2000.
3. Chung, T.J., Computational Fluid Dynamics, Cambridge University Press, 2003.

4. Anderson, D.A., Tannehill, J.C., and Pletcher, R.H., Computational Fluid Mechanics and Heat Transfer, McGraw Hill Book Company, 2002.

ME372	**ADVANCED IC ENGINES**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-Requisites:ME201: Engineering Thermodynamics, ME302: Prime Movers and Hybrid Vehicles

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

CO1	Understand the importance of IC engine as a prime mover and compare its performance on the basis of thermodynamic cycles and combustion process.
CO2	Identify harmful IC engine emissions and use viable alternate fuels in engines.
CO3	Analyze and evaluate engine performance and adopt improvement devices and new combustion concepts.
CO4	Classify and analyze alternate power sources for automobiles.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	2	-	1	-	-	-	-	-	-	1	2	3
CO2	-	2	3	2	-	2	2	-	-	-	-	1	3	2
CO3	3	2	2	-	2	-	1	-	-	-	-	1	3	3
CO4	2	-	2	-	-	1	2	-	-	-	-	1	2	2

Detailed Syllabus:

Introduction to IC engines: Overview of the course, Examination and Evaluation patterns-Classification of Prime Movers; IC Engines as Prime Movers; Historical Perspective-Contribution of IC Engines for Global Warming. Concept of charge, Differences between EC Engines, and IC Engines- Classification, Mechanical cycle and Thermodynamic cycle, Air standard cycles-Diesel, Otto, Dual and Miller cycles. Classification of 2-S cycle engines based on scavenging, Differences between 2-S and 4-S cycle engines, Differences between SI and CI engines.

Spark Ignition Engines: Flame Propagation- Combustion phenomena (Normal and Abnormal), Factors affecting, Detonation, Ignition quality, HUCR-Carburetion, and fuel injection systems for SI Engines.

Compression Ignition Engines: Advantages of CI engines-Importance of air motion and Compression Ratio, Mixture Preparation inside the CC. Normal and abnormal combustion - Ignition Quality-Cetane Number-Characteristics of a Good Combustion Chamber-Classification of Combustion Chambers (DI and IDI). Description of Fuel injection Systems -Individual, Unit and Common Rail (CRDI), Fuel Injectors-Nozzle types, Electronic Control Unit (ECU)-Numerical problems on fuel injection.

Supercharging of IC Engines: Need of Supercharging and advantages, Configurations of Supercharging-Numerical problems on turbocharging.

Pollutant emissions from IC Engines: Introduction to clean air, Pollutants from SI and CI Engines: Carbon monoxide, UBHCs, Oxides of nitrogen (NO-NOx) and Particulate Matter. Mechanism of formation of pollutants, Factors affecting pollutant formation. Measurement of engine emissions- instrumentation, Pollution Control Strategies, Emission norms-EURO and Bharat stage norms.

Performance of IC Engines: Classification of engine performance parameters-Measurement of brake power, indicated power and friction power. Factors affecting performance, Heat loss, Air-fuel ratio, Pumping loss, Energy Balance: Pi and Sankey diagrams Numerical problems.

Alternate Fuels: Need for Alternate fuels, Desirable Characteristics of good Alternate Fuel-Liquid and Gaseous fuels for SI and CI Engines, Kerosene, LPG, Alcohols, Biofuels, Natural gas, Hydrogen and use of these fuels in engines.

Batteries: Battery: lead-acid battery, advantages of lead- acid battery- Battery parameters: battery capacity, discharge rate, state of charge, state of discharge, depth of discharge, technical characteristics-Ragone plots.

Electric vehicles: Introduction: Limitations of IC Engines as prime mover, History of EVs, EV system, components of EV-DC and AC electric machines: Introduction and basic structure-Electric vehicle drive train-advantages and limitations, Permanent magnet and switched reluctance motors-EV motor sizing: Initial acceleration, rated vehicle velocity, Maximum velocity and maximum gradeability.

Hybrid vehicle: Configurations of hybrids, advantages and limitations-Hybrid drive trains, sizing of components Initial acceleration, rated vehicle velocity, Maximum velocity and maximum gradeability- Hydrogen: Production-Hydrogen storage systems-reformers.

Fuel Cell vehicles: Fuel cells: Introduction-Fuel cell characteristics, Thermodynamics of fuel cells-Fuel cell types: emphasis on PEM fuel cell.

Reading:

1. J.B. Heywood Internal Combustion Engine Fundamentals, McGraw Hill Co.1988.
2. W.W.Pulkrabek Engineering Fundamentals of IC Engine, PHI Pvt.Ltd 2002.
3. SethLeitman and Bob Brant Build your own electric vehicle McGraw Hill Co.2009.
4. F.Barbir PEM Fuel Cells-Theory and Practice Elsevier Academic Press-2005.

ME373	**CONVECTIVE HEAT TRANSFER**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-Requisites:ME201: Engineering Thermodynamics; ME352: Heat and mass transfer

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

CO1	Understand principles of forced and free convection heat transfer processes.
CO2	Formulate and solve convective heat transfer problems.
CO3	Estimate heat dissipation from heat transfer devices.
CO4	Evaluate energy requirements for operating a flow system with heat transfer.
CO5	Understand current challenges in the field of convective heat transfer.

Course Articulation Matrix:

PO / **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	1	1	3	2	-	-	-	-	-	-	-	3	3
CO2	3	3	3	2	2	-	-	-	-	-	-	1	2	2
CO3	3	2	2	2	1	-	-	-	-	-	-	1	2	2
CO4	3	2	3	2	1	-	-	-	-	-	-	1	2	3
CO5	3	2	1	2	2	-	-	-	-	-	-	2	2	1

Detailed Syllabus:

Introduction: Course structure, Basics of Thermodynamics, Fluid mechanics and Heat transfer.

Fundamental Principles: Continuity, momentum and energy equations, Reynold's transport theorem, Second law of TD, Rules of Scale analysis, Concept of Heat line visualization.

Laminar forced convection: External flows: Boundary layer concept, velocity and thermal boundary layer, Governing equations, Similarity solutions, various wall heating conditions, Flow over sphere, wedge, and stagnation flow.

Laminar forced convection: Internal flows: Fully developed laminar flow: Constant heat flux, Constant wall temperature, developing length.

External Natural convection: Governing equations for natural convection, Boussinesq approximation, Dimensional Analysis, Boundary layer equations, Scale analysis, Low and high Prandtl number fluids, vertical walls, horizontal walls, sphere.

Internal Natural Convection: Natural convection in enclosures: isothermal and constant heat flux. Sidewalls, triangular enclosures, heated from below, inclineden closures, annular space between horizontal cylinders.

Turbulent boundary layer flow: Boundary layer equations, mixing length model, flow over single cylinder, crossflow over array of cylinders, Natural convection along vertical walls, turbulent duct flow.

Reading:

1. Bejan, A., Convection Heat Transfer, John Willey and Sons, New York, 2001.
2. Louis, C. Burmeister, Convective Heat Transfer, John Willey and Sons, New York, 2003.
3. Kays, W.M. and Crawford, M. E., Convective Heat and Mass Transfer, McGraw Hill, 2001.

ME374	**ADVANCED METAL CASTING**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: ME203 – Production Processes and Management

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

CO1	Recommend remedies for the defects in castings.
CO2	Model components for castings using CAD tools.
CO3	Design gating system for metal casting processes
CO4	Perform economic and castability analysis using Auto-CAST software.

Course Articulation Matrix:

PO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3	-	3	-	-	-	-	-	-	-	3	2
CO2	3	2	2	-	2	-	-	-	-	2	-	-	3	2
CO3	3	2	3	-	3	-	-	-	-	-	-	-	2	3
CO4	3	2	2	-	2	-	-	-	-	2	-	-	1	3

Detailed syllabus:

Metal casting-overview: Applications and production, historical perspective, casting processes.

Solid modeling of castings: casting features, modeling techniques, graphical user interface, model representation model exchange formats, model verification.

Pattern, mould and core design: Orientation and parting, mould parting analysis, pattern design, cored features, core print design and analysis, mould cavity layout.

Feeder design and analysis: Casting solidification, solidification time and rate, feeder location and shape, feeder and neck design, feed aid design, solidification analysis, vector element method, optimization, and validation.

Gating design and analysis: Mould filling, gating system and types, gating channel layout, optimal filling time, gating element design, mould filling analysis, numerical simulation, optimization and validation.

Process planning and costing: Casting process selection, process steps and parameters, tooling cost estimation, material cost estimation, and conversion cost estimation.

Design for castability: Product design for castability, process friendly design, and castability analysis.

Reading:

1. B.Ravi, “Metal casting: CAD and Analysis”, PH Publication, 2014.
2. P.L.Jain, “Principles of Foundry Technology”, 2012.

ME375	DESIGN FOR MANUFACTURING AND ASSEMBLY	DEC	3-0-0	3 Credits

Pre-requisites: MM 235: Materials Engineering, ME304: Machine Tools and Machining Science

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

CO1	Utilize Design-for-Manufacturing concepts for effective product development
CO2	Estimate the cost of dies, molds and machined components based on die life.
CO3	Formulate appropriate design rules for forging, sheet metal forming, machining and powder metallurgy processes
CO4	Propose manual and automated assembly sequences using appropriate design rules

Course Articulation Matrix:

PO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	-	-	-	-	-	-	-	-	2	2
CO2	3	2	2	2	-	-	-	-	-	-	-	-	2	2
CO3	3	2	2	2	-	-	-	-	-	-	-	-	2	2
CO4	3	2	2	2	-	-	-	-	-	-	-	-	2	2

Detailed syllabus:

Introduction: Overview of the course, Design for manufacturing, Typical Case studies, Innovative product, and service designs.

Material Selection: Requirements for material selection, systematic selection of processes and materials, ASHBY charts

Design for Casting: Basic characteristics and Mold preparation, Sand casting alloys, Design rules for and castings, Example calculations, Investment casting overview, Cost estimation, Number of parts per cluster, Ready to pour liquid metal cast, Design guidelines for Investment casting, die casting cycle, Determination of optimum number of cavities, appropriate machine size, Die cost estimation, Design principles.

Design for Injection molding: Injection molding systems, Molds, molding cycle time, mold cost estimation, estimation of optimum number of cavities, Assembly techniques, Design Guidelines.

Design for Hot Forging: Characteristics of the forging process, forging allowances, flash removal, die cost estimation, die life, and tool replacement costs.

Design for Sheet metal working: Press selection, press brake operations, Design rules.

Design for Powder Metal processing: Powder metallurgy, tooling and presses for Compaction, Sintering, materials, heat treatments, Design guidelines.

Design for machining: Machining using single point cutting tools, multipoint cutting tools, abrasive wheels, Assembly, cost estimation for machined components, Design guidelines.

Design for Assembly: Historical Development, Choice of Assembly method, social effects of automation, Design guidelines for Manual assembly, Analysis of an assembly, Development ofa systematic DFA analysis method, DFA index, classification system for manual handling, Manual insertion and fastening.

Reading:

1. Geoffrey Boothroyd, Dewhurst P., Knight W., "Product design for manufacture and assembly", CRC press, 2002
2. George E. Dieter, "Engineering Design - A material processing approach", 5th Edition, McGraw Hill International, 2003.
3. ASM Handbook, "Design for manufacture", 2000.

ME376	**MACHINE TOOL DESIGN**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: ME203: Production Process and Management, ME301: Design of Machine Elements, ME304: Machine Tools and Machining Science

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

CO1	Design and analyze kinematic motions in a machine tool.
CO2	Design and analyze speed and feed gear boxes.
CO3	Design machine tool structures for strength and rigidity.
CO4	Analyze machine tool vibration and chatter.
CO5	Select alignment tests to be performed on a machine tool for quality assurance.

Course Articulation Matrix:

PO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	3	3	-	-	-	-	-	-	-	-	3	2
CO2	3	-	3	3	-	-	-	-	-	-	-	-	3	2
CO3	3	2	3	3	-	-	-	-	-	-	-	-	3	2
CO4	3	3	3	2	-	-	-	-	-	-	-	-	3	2
CO5	3	-	3	2	-	-	-	-	-	-	-	-	3	2

Detailed syllabus:

Introduction to Machine Tool Drives and Mechanisms: Introduction to the course, Working and Auxiliary Motions in Machine Tools, Kinematics of Machine Tools, Motion Transmission.

Regulation of Speeds and Feeds: Aim of Speed and Feed Regulation, Stepped Regulation of Speeds, Multiple Speed Motors, Ray Diagrams and Design Considerations, Design of Speed Gear Boxes, Feed Drives, Feed Box Design.

Design of Machine Tool Structures: Functions of Machine Tool Structures and their Requirements, Design for Strength, Design for Rigidity, Materials for Machine Tool

Structures,
Machine Tool Constructional Features, Beds and Housings, Columns and Tables, Saddles and Carriages.

Design of Guideways, Power Screws and Spindles: Functions and Types of Guideways, Design of Guideways, Design of Aerostatic Slideways, Design of Anti-Friction Guideways, Combination Guideways, Design of Power Screws.

Design of Spindles and Spindle Supports: Functions of Spindles and Requirements, Effect of Machine Tool Compliance on Machining Accuracy, Design of Spindles, Antifriction Bearings.

Dynamics of Machine Tools: Machine Tool Elastic System, Static and Dynamic Stiffness.

Acceptance Tests: Alignment tests on lathe, drilling and milling machines.

Reading:

1. N.K. Mehta, **"**MachineTool Design and Numerical Control", TMH, New Delhi, 2010.
2. G.C. Sen and A. Bhattacharya**, "**Principles of Machine Tools", New Central Book Agency, 2009.
3. D. K Pal, S. K. Basu, “Design of Machine Tools”, 5th Edition, Oxford IBH, 2008.
4. N. S. Acherkhan, “Machine Tool Design”, Vol. I, II, III and IV, MIR publications, 1968.

ME377	**THEORY OF ELASTICITY**	**DEC**	**3-0-0**	**3 Credits**

Pre-Requisites: Nil

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

CO1	Formulate the stress strain relations in elastic body.
CO2	Develop the governing equation and apply boundary conditions for 2D elastic problems.
CO3	Apply the general theorems to the 3D elastic continuum problems.
CO4	Analyze the stress in the Prismatic Beams of rectangular and circular cross-section

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	-	-	-	-	-	2	-	-	-	2	-	-
CO2	-	3	3	2	2	-	-	2	-	-	-	2	2	2
CO3	3	3	-	-	3	-	-	2	-	-	-	2	2	2
CO4	-	3	-	`2	3	-	-	2	-	-	-	2	3	2

Detailed Syllabus:

Elasticity: Two-dimensional stress analysis - Deformation and Strain Tensor, Traction and Stress Tensor Plane stress - Plane strain - Equations of compatibility - Stress function - Boundary conditions.

Rectangular Coordinates System: Stress, Strain and Displacement Transformations, Solution by polynomials - Saint Venent's principles - Determination of displacement - Simple beam problems, Problems in polar coordinates - General equations in polar coordinates - Stress distribution symmetrical about axis - Strain components in polar coordinates - Simple and symmetric problems.

Three-Dimensional Classical Elasticity Problems: Principle stresses - Homogeneous deformations - Strain spherical and deviatoric stress - Hydrostatic strain.

General Theorems: Differential equations of equilibrium and compatibility - Displacement - Uniqueness
of solution - Reciprocal theorem, Boussinesq's Problem, Mindlin's Problem.

Bending of Prismatic Bars and Elasto dynamics: Stress function - Bending of cantilever beam - Beam of rectangular cross-section - Beams of circular cross-section, Helmholtz Decomposition, Elastic Wave Propagation in Solids

Reading:

1. Theory of Elasticity by Timoshenko, S.P. and Goodier, J.N. McGraw-Hill, 1970.
2. An Engineering Theory of Plasticity by E.P. Unksov Butter worths, 1961
3. A Treatise on the mathematical Theory of Elasticity, Love. FB & C Limited, 2017
4. Fundamentals of Fracture Mechanics, T. Kundu, Taylor and Francis, 2008

ME378	**DESIGN AND ANALYSIS OF EXPERIMENTS**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: Nil

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

CO1	Identify objectives and key factors in designing experiments.
CO2	Develop appropriate experimental design to conduct experiments.
CO3	Analyze experimental data and draw valid conclusions.
CO4	Develop empirical models using experimental data to optimize process parameters.
CO5	Design robust products and processes using parameter design approach.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	2	-	-	-	-	-	2	2	2	2	3	2
CO2	3	3	3	3	2	-	-	-	2	-	2	2	3	3
CO3	3	3	2	3	2	-	-	-	2	3	-	2	3	3
CO4	3	3	3	3	3	-	-	-	2	-	2	2	3	2
CO5	3	-	3	-	3	-	-	-	2	-	3	2	3	3

Detailed Syllabus:

Fundamentals of Experimentation: Role of experimentation in rapid scientific progress, Historical perspective of experimental approaches, Steps in experimentation, Principles of experimentation.

Simple Comparative Experiments: Basic concepts of probability and statistics, Comparison of two means and two variances, Comparison of multiple (more than two) means & ANOVA.

Experimental Designs: Factorial designs, fractional factorial designs, orthogonal arrays, standard orthogonal arrays & interaction tables, modifying the orthogonal arrays, selection of suitable orthogonal array design, analysis of experimental data.

Response Surface Methodology: Concept, linear model, steepest ascent, second order model, regression.

Taguchi's Parameter Design: Concept of robustness, noise factors, objective function & S/N ratios, inner-array and outer-array design, data analysis.

Reading:

1. Montgomery D. C. “Design and Analysis of Experiments”, 7thEdition, John Wiley & Sons, 2008.
2. Ross P. J. “Taguchi Techniques for Quality Engineering”, McGraw-Hill, NY, 2008.

ME379	**TRIBOLOGY**	**DEC**	**3 - 0 - 0**	**3 credits**

Pre-Requisites: CE101 Engineering Mechanics

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

CO1	Analyze properties of lubricant and selection of proper lubricant for the given application.
CO2	Identify the lubrication regime for the given mechanical application.
CO3	Determine tribological performance parameters of sliding contact in hydrodynamic lubrication regimes.
CO4	Evaluate the friction and wear behavior of the given materials.

Course Articulation Matrix:

PO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	2	2	1	-	-	-	-	2	3	2
CO2	3	2	2	2	3	2	1	-	-	-	-	2	3	3
CO3	3	2	3	3	3	2	1	-	-	-	-	2	3	3
CO4	3	3	3	3	3	2	1	-	-	-	-	2	3	3

Detailed Syllabus:

Introduction: History and basic concept of friction wear and lubrication, Types of lubricants, Objectivesand selection of lubricant, Physical properties of lubricants.

Lubrication: Regimes of lubrication - hydrodynamic, Elasto-hydrodynamic, mixed and boundary lubrication, Reynolds' equation, Hydrodynamic lubrication of roughened surfaces.

Theories of other Lubrication: Externally pressurized lubrication, Squeeze-film lubrication, Elasto-hydrodynamic lubrication, Rheological lubrication regime, Functional lubrication regime.

Applications of hydrodynamic lubrication theory - Journal bearing, inclined thrust pad bearing, Rayleigh step bearing.

Friction and Wear: Origin of sliding friction, Causes of Friction, Laws of Rolling Friction. Friction Instability, contact between two bodies in relative motion, Wear classification - Wear between solids - Wear between solid and liquid - Factors affecting wear - Measurement of wear, Types of wear and their mechanisms - Adhesive wear-adhesion junction growth, Abrasive wear, wear due to surface fatigueand wear due to chemical reactions, wear of metallic materials.

Reading:

1. Stachowaik, G.W., Batchelor, A.W., *Engineering Tribology*, 3rd Ed., Elsevier, 2010.
2. Majumdar B.C, *Introduction to bearings*, S. Chand & Co., Wheeler publishing, 1999.
3. Andras Z. Szeri, *Fluid film lubrication theory and design*, Cambridge University press, 1998.
   Stolarski TA, *Tribology in Machine Design*, Butterworth Heinemann, 2000.

ME380	**PRODUCTION PLANNING AND CONTROL**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: ME370: Management Science and Productivity.

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

CO1	Explain production systems and their characteristics.
CO2	Evaluate MRP and JIT systems against traditional inventory control systems.
CO3	Evaluate basics of variability and its role in the performance of a production system.
CO4	Analyze aggregate planning strategies.
CO5	Apply forecasting and scheduling techniques to production systems.
CO6	Apply theory of constraints for effective management of production systems.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	2	2	-	-	-	-	-	2	-	2	2	2	2
CO2	3	3	3	-	3	2	-	-	2	2	2	2	2	2
CO3	2	3	3	-	-	-	-	-	2	-	2	3	2	2
CO4	3	3	3	3	3	-	-	-	2	2	2	2	2	3
CO5	3	3	3	3	3	2	-	-	2	-	2	2	2	3
CO6	2	3	3	2	-	-	-	-	2	-	2	2	2	2

Detailed Syllabus:

Introduction to Production Systems: Production Systems: Classification & Characterization,Overview of Production Planning and Control issues, Review of EOQ & inventory control systems.

Material Requirement Planning: Dependent Demand & Material Requirement Planning, Structure ofMRP system, MRP Calculations, Planning Issues, Implementation Issues.

Just in Time Production Systems: Just-in-Time System: Evolution, Characteristics of JIT Systems,Continuous Improvement, Kanban System, Strategic Implications of JIT System.

Factory Physics: Basic factory dynamics, Variability basics, Push and pull production systems.

Aggregate Planning: Aggregate Planning: Purpose & Methods, Reactive and Aggressive Alternatives,Planning Strategies, LP Formulation, Master Production Scheduling.

Scheduling: Scheduling in Manufacturing, Sequencing Operations for One Machine, Sequencing Operations for a two-station Flow Shop, Job Shop Dispatching.

Forecasting Methods: Demand Forecasting: Principles and Methods, Judgment methods, Causalmethods, Time-series methods.

Theory of Constraints: Concept of bottleneck, Local and global optima, Five steps of TOC approach,Performance measures.

Reading:

1. Krajewski L.J. and Ritzmen L.P., “Operations Management: Strategy and Analysis”, 9th Edition, Pearson Education, 2010.
2. Chase R.B. Jacobs F.R. and Aquilano N.J., “Operations Management for Competitive Advantage”, 11th Edition, Tata McGraw Hill Book Company, New Delhi, 2010.
3. Hopp W. J. and Spearman M. L. “Factory Physics: Foundations of Manufacturing Management”, McGraw Hill International Edition, 3rd Edition, 2008.
4. Mukhopadhyay S.K., “Production Planning and Control”, 2nd Edition, PHI, Eastern Economy Edition, 2013.

Department Elective 3

ME411	**JET PROPULSION AND ROCKETRY**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-Requisites:ME201: Engineering Thermodynamics, ME252: Turbomachines

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

CO1	Understand the applications of jet and rocket propulsion and their energy requirements.
CO2	Identify propellants available and factors influencing their burn rate and performance.
CO3	Classify nozzles and their requirements for the development of thrust and impulse.
CO4	Understand the principles of rocket propulsion, staging and boosting.
CO5	Evaluate burn rate, propulsive power, thrust and energy requirements in ideal cases of propulsion devices.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	3	2	1	-	-	-	-	-	-	1	2	2
CO2	3	3	2	3	-	-	-	-	-	-	-	1	2	2
CO3	3	3	2	2	2	-	-	-	-	-	-	1	-	2
CO4	3	3	3	2	2	-	-	-	-	-	-	1	2	2
CO5	3	3	3	3	2	-	-	-	-	-	-	1	2	2

Detailed Syllabus:

Motion In Space-Requirements of Orbit: Introduction, Motion of Bodies in Space and Laws of Motion; Parameters describing Motion of Bodies, Newton's laws of Motion, Universal Law of Gravitational Force, Gravitational Field; Requirements for Motion in Space, Geosynchronousand Geostationary Orbits, Eccentricity and Inclination of Orbits, Energy and VelocityRequirements to reach a Particular Orbit; Escape Velocity, Freely Falling Bodies, Means of Providing the Required Velocities, small problems.

Theory of Rocket Propulsion: Illustration by an Example of Motion of Sled Initially at Rest, Motion of Giant Squid in Deep Seas; Rocket Principle and the Rocket Equation, Mass Ratio of a Rocket, Desirable Parameters of a Rocket, Propulsive Efficiency of a Rocket, Performance Parameters of a Rocket, Staging and Clustering of Rockets, Classification of Rockets, problems.

Rocket Nozzle and Performance: Expansion of gas from a high pressure chamber, Shape of the Nozzle, Nozzle area Ratio, Performance loss in a conical Nozzle, Flow Separation in Nozzles Contour or Bell Nozzles, Unconventional Nozzles Mass Flow rates and characteristic Velocity, Thrust developed by a Rocket; Thrust Coefficient Efficiencies, Specific Impulse and Correlation with C* and CF General Trends.

Chemical Propellants: Small Values of Molecular Mass and Specific Heat Ratio, Energy Release during Combustion of Propellants, Criterion for Choice of Propellants, Solid Propellants, Liquid Propellants, Hybrid Propellants.

Solid Propellant Rockets: Mechanism of Burning and Burn Rate, Choice of Index n for Stable Operation of Solid Propellant Rockets, Propellant Grain Configuration, Ignition of Solid Propellant Rockets, Pressure Decay in the chamber after propellant Burns Out, Action time and Burn Time, Factors influencing Burn Rate Components of a Solid Propellant Rocket.

Liquid Propellant Rockets: Propellant Feed system, Thrust Chamber, Performance and Choice of Feed System Cycle, Turbo-pumps, Gas requirements for draining of propellants from storage tanks, draining under microgravity conditions, Complexity of Liquid Propellant Rockets and simulation, Trends in the development of liquid propellant rockets.

Liquid Monopropellant rockets: Hydrazine, Monopropellant rockets, Catalyst bed loading, Performance, and applications.

Hybrid Rockets: Working Principle, Choice of Fuels and Oxidizers, Future of Hybrid Rockets.

Combustion Instability: Bulk and wave modes of Combustion Instability, Analysis procedure for bulk mode of combustion, Instability in liquid propellant rockets, Bulk mode of combustion instability in solid Propellant Rockets, Wave mode of combustion instability, Wave mode instability in solid propellant rockets, Evaluation of the growth constant of solid propellant usingT burner, Conversion of growth constant derived from T burner for application in a solid propellant rocket, Wave mode instability in liquid propellant rockets, Non-linear combustion instability, Process induced combustion instability, Pogo instability due to interaction of propulsion and structure, Combustion Instability: Suppression and Control.

Reading:

1. Barrere, M., Rocket Propulsion, Elsevier Pub. Co., 1990.
2. Sutton, G. P., Rocket Propulsion Elements, John Wiley, New York, 1993.

3. Ramamurthi K., Rocket Propulsion, Macmillan Publishers India Ltd., 2010.
4. Feedesiev, V. I. and Siniarev, G. B., Introduction to Rocket Technology, Academic Press, New York, 2000.
5. Sarvanamuttoo, H.I.H., Rogers, G. F. C. and Cohen, H., Gas Turbine Theory, 6th Edition, Pearson Prentice Hall, 2008.

ME412	**HEATING, VENTILATION & AIR-CONDITIONING**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-Requisites:ME201: Engineering Thermodynamics

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

CO1	Understand the fundamentals of Psychrometry
CO2	Apply human comfort indices and comfort chart to design indoor conditions of HVAC systems.
CO3	Estimate heating and cooling loads for buildings according to ASHRAE procedures/standards.
CO4	Design and evaluate complete air distribution system including fan, duct, and installation requirements for a typical HVAC system.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	-	-	-	-	-	-	-	-	-	2	1	1
CO2	3	3	3	-	-	2	2	-	2	-	2	2	2	2
CO3	3	3	3	-	-	-	3	-	3	-	-	3	2	2
CO4	3	3	3	-	-	-	3	-	3	-	-	3	3	3

Detailed Syllabus:

Introduction: Brief history of air conditioning and impact of air conditioning. HVAC systems and classifications, Heat Pumps

Psychrometry of Air Conditioning Processes: Thermodynamic properties of moist air, Important Psychrometry properties, Psychometric chart; Psychrometric process in air conditioning equipment, applied Psychrometry, air conditioning processes, air washers.

Comfort Air Conditioning: Thermodynamics of human body, metabolic rate, energy balance and models, thermoregulatory mechanism. Comfort & Comfort chart, Effective temperature, Factors governing optimum effective temperature, Design consideration. Selection of outside and inside design conditions.

Heat Transfer Through Building Structures: Solar radiation; basic concepts, sun-earth relationship, different angles, measurement of solar load, Periodic heat transfer through walls and roofs. Empirical methods to calculate heat transfer through walls and roofs using decrement factor and time lag method. Infiltration, stack effect, wind effect. CLTD/ETD method - Use of tables, Numerical and other methods, Heat transfer through penetration - Governing equations, SHGF/SC/CLF Tables.

Load Calculation: Types of air-conditioning systems, General consideration, internal heat gains, system heat gain, cooling and heating load estimate.

Ventilation System: Introduction- Fundamentals of good indoor air quality, need for building ventilation, Types of ventilation system, Air Inlet system. Filters heating & cooling equipment, Fans, Duct design, Grills, Diffusers for distribution of air in the workplace.

Reading:

1. F.C. McQuiston& J.D. Parker, “Heating Ventilating and Air Conditioning- Analysis and Design”, 5th Ed., John Wiley & Sons, 2001.
2. J.L. Threlkeld, “Thermal Environmental Engineering”, 2nd Ed., Prentice-Hall, Inc., 1970.
3. ASHRAE Handbooks: Fundamentals, HVAC Applications, HVAC Systems & Equipment.
4. R.C. Arora, “Refrigeration & Air conditioning”, PHI, 2010.

ME413	**CRYOGENICS**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-Requisites: Nil

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

CO1	Understand principles of cryogenic systems.
CO2	Understand air and helium liquefaction processes.
CO3	Classify cascade refrigeration systems.
CO4	Understand principles of ultra-low temperature systems and their applications.
CO5	Evaluate storage systems used in cryogenic applications.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	-	-	-	-	-	-	-	-	-	-	2	2
CO2	3	3	3	3	3	-	-	-	-	-	-	-	3	2
CO3	3	3	3	-	3	-	-	-	-	-	-	-	3	3
CO4	3	3	2	2	3	-	-	-	-	-	-	-	3	3
CO5	3	3	2	3	3	-	-	-	-	-	-	-	3	2

Detailed Syllabus:

Introduction: Definition and Engineering Applications of Cryogenics, Properties of solids for cryogenic systems.

Refrigeration and Liquefaction: Simple Linde cycle, Pre-cooled Joule-Thomson cycle, dual- pressure cycle, Simon helium liquefier, classical cascade cycle, mixed-refrigerant cascade cycle.

Ultra-low-temperature refrigerators: Definition and Fundamentals regarding ultra-low-temperature refrigerators, Equipment associated with low-temperature systems, Various Advantages and Disadvantages.

Storage and Handling of Cryogenic Refrigerants: Storage and Transfer systems, Insulation, Various Types of Insulation typically employed, Poly Urethane Foams (PUFs) and Polystyrene Foams (PSFs), Vacuum Insulation, and so on.

Applications: Broad Applications of Cryogenic Refrigerants in various engineering systems.

Reading:

1. Mamata Mukhopadhyay, Fundamentals of Cryogenic Engineering, PHI, 2010.
2. Thomas Flynn, Cryogenic Engineering, Revised and Expanded, CRC, 2004.
3. Arora and Domukundwar, Refrigeration and Air-conditioning, Dhanpat Roy & Co., 2018.
4. A. R. Jha, Cryogenic Technology and Applications, Butterworth-Heinemann, 2005.
5. Timmerhaus et. al., Cryogenic Engineering, Fifty Years of Progress, Springer, 2007.

ME414	**MICRO AND NANO MANUFACTURING**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: ME304: Machine Tools and Machining Science,

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

CO1	Understand manufacturing considerations at the micro and nano scale.
CO2	Create and characterize nanostructures for a particular industrial application
CO3	Select appropriate manufacturing methods to create micro sized components
CO4	Design and select industrially - viable processes, equipment and manufacturing tools forspecific industrial products

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	2	2	3	-	-	-	-	-	-	-	2	2
CO2	2	2	2	3	2	-	-	-	-	-	-	-	2	2
CO3	3	2	2	2	3	-	-	-	-	-	-	-	2	3
CO4	3	3	3	2	3	-	-	-	-	-	-	-	2	3

Detailed Syllabus:

Introduction: Importance of Nanotechnology, Emergence of Nanotechnology, Bottom-upand Top-down approaches, challenges in Nanotechnology.

Nano materials Synthesis and Processing: Methods for creating Nanostructures; Processes for producing ultra-fine powders - Mechanical grinding; Wet Chemical Synthesis of nanomaterials - sol-gel process, Liquid solid reactions; Gas Phase synthesis of nanomaterials- Furnace, Flame assisted ultrasonic spray pyrolysis; Gas Condensation Processing GPC), Chemical Vapour Condensation (CVC)- Cold Plasma Methods, Laser ablation, Vapour - liquid -solid growth, particle precipitation aided CVD, summary of Gas Condensation Processing (GPC).

Structural Characterization: X-ray diffraction, small angle X-ray Scattering, Optical Microscope and their description, Scanning Electron Microscopy (SEM), Scanning Probe
Microscopy (SPM), TEM and EDAX analysis, Scanning Tunneling Microscopy (STM), Atomic force Microscopy (AFM).

Microfabrication Techniques: Lithography, Thin Film Deposition and Doping, Etching and Substrate Removal, Substrate Bonding. MEMS Fabrication Techniques, Bulk Micromachining: Processes used for shaping and sizing of microproducts and macro products and Nano finishing techniques, Surface Micromachining, High- Aspect-Ratio Micromachining.

Nanofabrication Techniques: E-Beam and Nano-Imprint Fabrication, Epitaxy and Strain Engineering, Scanned Probe Techniques, Self-Assembly and Template Manufacturing.

MEMS devices and applications: Pressure sensor, inertial sensor, Optical MEMS, and RF-MEMS, Micro-actuators for dual-stage servosystems.

Reading:

2. Tai-Ran Hsu, "MEMS and Microsystems: Design and Manufacture," McGraw- Hill, 2008.
3. V. K. Jain, "Introduction to Micromachining", 2nd Edition, Alpha Science, 2014.
4. Mark James Jackson, "Microfabrication and Nanomanufacturing", CRC Press, 2005.
5. Gabor L. Hornyak, H.F. Tibbals, Joydeep Dutta & John J Moore, "Introduction toNanoscience and Nanotechnology", CRC Press, 2009.
6. Ray F. Edgerton, "Physical Principles of Electron Microscopy: An Introduction to TEM,SEM, and AEM", Springer, 2005.
7. B.D. Cullity, "Elements of X-Ray Diffraction", 3rd Edition, Prentice Hall, 2002.

ME415	**ADVANCED METAL FORMING**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: ME203: Production Process and Management

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

CO1	Solve for strain rates, temperatures, and metallurgical states in forming problems using constitutive relations.
CO2	Develop process maps for metal forming processes using plasticity principles.
CO3	Estimate formability limits for sheets and bulk metals.
CO4	Analyze the deformation process parameters for different engineering components.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	3	-	-	-	-	-	-	-	-	-	3	3
CO2	3	3	3	2	2	2	2	-	-	-	-	-	3	3
CO3	3	3	3	2	2	2	2	-	-	-	-	-	3	3
CO4	3	3	3	-	-	-	-	-	-	-	-	-	3	3

Detailed Syllabus:

Introduction: Introduction of metal forming as a manufacturing process and its relationship with other processes, Metal Forming from systems point of view, Advantages of metal forming as a manufacturing process, Classifications of metal forming processes, Forming equipment, Presses (mechanical, hydraulic).

Theoretical analysis: Theory of plasticity, Stress-strain relationship, Strain hardening, Material incompressibility, Work of plastic deformation, Work hardening, Yield criteria, Flow rule, Yield criterion and flow rule for Anisotropic material, Initiation, and extent of plastic flow- Upper Bound - Slip-Line-Slab Analysis - Problems.

Bulk Forming Processes: Forging; open-die forging, closed-die forging, coining, nosing, upsetting, heading, extrusion and tooling, Rod, wire, and tube drawing, rolling; flat rolling, shape rolling and tooling, spinning, hydro forming, rubber-pad forming, explosive forming, problems.

Sheet Forming Processes: Blanking, piercing, press bending, deep drawing, stretch forming, formability tests, forming limit diagrams, process simulation for deep drawing and numerical approaches, Case studies.

Problems & Case Studies: Case studies on the manufacturing aspects of products using the lessons learnt.

Reading:

1. R. Narayanasamy, R Ponalagusamy, “Theory of Engineering Plasticity”, Ahuja Book Company, 2000.
2. Henry S. Valberg, “Applied Metal Forming - Including FEM Analysis”, Cambridge University Press, 2010.
3. G.K. Lal, P.M. Dixit and N.Venkat Reddy, “Modeling Techniques for Metal Forming Processes“, Alpha Science, 2011

ME416	DESIGN AND ANALYSIS OF ENGINEERING MATERIALS	DEC	3 - 0 - 0	3 Credits

Pre-requisites: MM 235: Materials Engineering,

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

CO1	Understand the principles of materials selection and design.
CO2	Design components using appropriate attribute limits and material indices.
CO3	Establish the criteria for material qualification and acceptance.
CO4	Apply design principles for manufacturing of different engineering components.

Course Articulation Matrix:

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	2	-	-	-	-	-	-	2	3	2
CO2	3	3	2	2	2	-	-	-	-	-	-	2	2	2
CO3	3	3	2	2	2	-	-	-	-	-	-	2	-	2
CO4	3	3	2	2	2	-	-	-	-	-	-	2	2	2

Detailed Syllabus:

Introduction: The families of engineering materials. The Design process, types of design, Design tools and materials data.

Material Selection-The basic and case studies: Introduction and synopsis, the selection strategy, attribute limits and material indices, the selection procedure, computer-aided selection, the structural index, summary and conclusions, case studies.

Selection of material and shape, case studies: Introduction and synopsis, shape factors, Microscopic or Micro-structural shape factors, limits to shape efficiency, exploring and comparing structural sections, material indices that include shape, co-selecting material and shape, summary and conclusions, case studies.

Designing Hybrid Materials and case studies: Introduction and synopsis, filling holes in material property space, hybrids of type 1, 2, 3, 4. Summary and conclusions, case studies.

Reading:

1. G.S. Ramaswamy, “Design and Construction of Concrete Shell Roofs”, 1st Edition, CBS Publishers, 2005.
2. R. Szilard, “Theory and Analysis of Plates - Classical and Numerical Methods”, Prentice Hall, 1974.
3. Timoshenko and Krierger, “Theory of Plates and Shells”, 2nd Edition, Tata McGraw Hill,2010.

ME417	**CONDITION MONITORING**	**DEC**	**3-0-0**	**3 Credits**

Pre-requisites: ME367: Mechanical Vibrations

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

CO1	Understand effective maintenance schemes in industries
CO2	Diagnose the mechanical systems by applying vibration monitoring techniques
CO3	Apply oil analysis technique to diagnose the wear debris.
CO4	Identify nonconventional methods for machine diagnoses.
CO5	Develop modern technologies for effective plant maintenance.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	-	3	-	-	-	-	-	2	2	-	-	2	3	-
CO2	3	2	2	-	3	-	-	2	2	-	-	2	3	3
CO3	3	2	2	-	3	-	-	2	2	-	-	2	3	-
CO4	-	3	-	-	3	-	-	2	2	-	-	2	-	-
CO5	3	-	3	3	-	-	-	2	2	-	-	2	3	3

Detailed Syllabus:

Introduction: Failures - System, component, and services failures - classification and its causes, Maintenance Schemes - objectives - types and economic benefits, break down, preventive and predictive monitoring.

Vibration Monitoring - causes and effects of vibration, review of mechanical vibration concepts - free and forced vibrations, vibration signature of active systems - measurement of amplitude, frequency, and phase.

Vibration monitoring equipment- vibration sensors (contact and non-contact type) -factors affecting the choice of sensors, signal conditioners, recording and display elements, vibration meter and analyzers, measurement of overall vibration levels.

Contaminant analysis: Contaminants in used lubricating oils - monitoring techniques (wear debris) - SOAP technique, Ferrography, X-ray spectrometry, Particle classification.

Temperature Monitoring - Various techniques - thermograph, pyrometers, indicating paint and NDT methods.

Special Techniques: Ultrasonic measurement method, shock pulse measurement, Kurtosis, Acoustic Emission mentoring, critical speed analysis, shaft orbit analysis, Cepstrum analysis. Non-destructive techniques, Structural health monitoring weldments for surface and subsurface cracks

Reading:

1. Rao J. S., Vibration Condition Monitoring, Narosa Publishing House, 2/e 2000.
2. Isermann R., Fault Diagnosis Application, Springer-Verlag Berlin, 2011.
3. Allan Davis, Handbook of Condition Monitoring, Chapman, and Hall, 2000.
4. Choudary K K., Instrumentation, Measurement and Analysis, Tata McGraw Hill, 2012
5. Collacott, R. A., Mechanical Faults Diagnosis, Chapman and Hall, London, 1990

ME418	**THEORY OF PLASTICITY**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: Nil

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

CO1	Differentiate elastic and plastic behavior from stress-strain curves
CO2	Identify plastic yield criteria to establish constitutive modeling
CO3	Interpret material constants in mathematical formulation of constitutive relationship
CO4	Analyze boundary value problems with elasto-plastic properties

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	2	2	-	-	-	-	-	-	-	-	3	3
CO2	3	2	2	2	-	-	-	-	-	-	-	-	3	3
CO3	2	3	2	-	-	-	-	-	-	-	-	-	3	3
CO4	2	3	2	-	-	-	-	-	-	-	-	-	3	3

Detailed syllabus:

Introduction to the concept of plastic deformation-Role of microstructure and thermodynamics in plastic deformation - Constitutive responses: elastic, viscoelastic, plastic, visco-plastic, anisotropy etc.

Physical overview of crystal plasticity, plasticity of granular media, plasticity in rubber-like materials, etc. (Rate independent plastic deformation) - Rate dependent and rate independent plasticity - Plastic strain, incremental strain, objective rates, and hardening variables - Yield criteria - Plastic work (Drucker's postulate) - Maximum dissipation and normality rule (Associated flow rules) - Hardening rules (isotropic and kinematic) - non-associated flow rules

Axisymmetric problems in plasticity - Basic equations of plane strain and plane stress - Slip lines and their properties - Limit analysis and shakedown theorems (Plastic stability and waves) - Concept of plastic stability - Global stability criteria according to Hill - Elastoplastic column buckling - Local stability criteria (localization, shear bands, ellipticity)

Introduction to dynamic plasticity - One-dimensional - Phase transformation and plasticity, strain-gradient plasticity, dislocation plasticity, crystal plasticity.

Reading:

1. J. Lubliner, “Plasticity Theory”, Dover Publishing, 2008.
2. L. M. Kachanov, “Fundamentals of the theory of plasticity”, Dover Publishing, 1990.
3. D. Bigoni, “Nonlinear Solid Mechanics”, Cambridge University Press, 2012
4. P. M. Dixit and U. S. Dixit, “Plasticity: Fundamentals and applications”, CRC Press; (2014)
5. J. Chakrabarty, “Theory of Plasticity”, 3rd Edition, Butterworth-Heinemann, 2006.
6. R Narayanasamy and R Ponalagusamy, “Theory of Engineering Plasticity”, Ahuja Book Company, 2000.

ME419	**ROBOTICS**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: Nil.

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

CO1	Understand the basic components of robots, classification and robot grippers.
CO2	Model forward and inverse kinematics of robot manipulators.
CO3	Analyze forces in links and joints of a robot.
CO4	Programme a robot to perform tasks in industrial applications.
CO5	Design intelligent robots using sensors.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	1	-	-	-	1	-	-	-	-	-	2	1	1
CO2	3	2	2	2	2	2	-	-	-	-	-	2	2	2
CO3	3	2	2	2	2	2	-	-	-	-	-	2	2	2
CO4	3	3	3	`3	3	3	-	-	-	-	-	2	3	3
CO5	3	2	3	3	3	3	-	-	-	-	-	2	3	3

Detailed Syllabus:

Introduction: Robotics-classification, Sensors-Position sensors, Velocity sensors, Proximity sensors, Touch and Slip Sensors, Force and Torque sensors. Grippers and Manipulators-Gripper joints, Gripper force, Serial manipulator, Parallel Manipulator, selection of Robot-Selection based on the Application

Kinematics: Manipulators Kinematics, Rotation Matrix, Homogenous Transformation Matrix, Directand Inverse Kinematics for industrial robots for Position and orientation.

Statics & dynamics: Differential Kinematics and static- Dynamics-Lagrangian Formulation, Newton Euler Formulation for RR & RP Manipulators,

Trajectory planning: Motion Control- Interaction control, Rigid Body mechanics.

Control: architecture- position, path velocity and force control systems, computed torque control, Adaptive control, and Servo system for robot control.

Robot programming: Programming of Robots and Vision System- overview of various programming Languages.

Applications: Application of Robots in production systems- Application of robot in welding, machine tools, material handling, and assembly operations parts sorting and parts inspection.

Reading:

1. Craig, J.J., *Introduction to Robotics Mechanics and Control*, Addison Wesley, 1999.
2. Saha, Subir Kumar. Introduction to robotics. Tata McGraw-Hill Education, 2014.
3. Spong, Mark W., Seth Hutchinson, and Mathukumalli Vidyasagar. Robot modeling and control. Vol. 3. New York: Wiley, 2006.

ME420	**TOTAL QUALITY MANAGEMENT**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: Nil

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

CO1	Understand quality management philosophies, techniques, and frameworks
CO2	Adopt TQM methodologies for continuous quality improvement
CO3	Identify the areas of improvement through measurement of cost of poor quality, effectiveness, and efficiency of processes
CO4	Apply TQM process and concepts to enhance the performance of systems
CO5	Understand the implications of quality management standards and systems

Course Articulation Matrix

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	-	-	-	-	-	-	3	2	2	2	2	2	2
CO2	2	-	-	-	-	2	-	3	2	2	2	2	2	2
CO3	2	-	-	-	2	3	-	3	2	2	2	2	3	2
CO4	2	2	-	3	3	2	-	3	3	3	3	2	2	3
CO5	2	2	-	-	2	2	-	3	2	2	2	2	3	2

Detailed syllabus:

Introduction: Definition of Quality, Dimensions of Quality, Definition of Total quality management, Quality Planning, Quality costs - Analysis, Techniques for Quality Costs, and Basic concepts of Total Quality Management.

Historical Review: Quality Council. Quality Statements, Strategic Planning, Deming Philosophy, Barriers to TQM Implementation, Benefits of TQM, Characteristics of successful quality leader, Contributions of Gurus of TQM, Case studies.

TQM Principles: Customer satisfaction - Customer Perception of Quality, Customer Complaints, Service Quality. Customer Retention, Employee Involvement - Motivation, Empowerment teams, Continuous Process Improvement - Juran Trilogy, PDSA Cycle, Kaizen, Supplier Partnership - Partnering, sourcing, Supplier Selection, Supplier Rating, Relationship Development, Performance Measures - Basic Concepts, Strategy, Performance Measure, Case studies.

TQM Tools: Benchmarking - Reasons to Benchmark, Benchmarking Process, Quality Function Deployment (QFD) - House of Quality, QFD Process, Benefits, Taguchi Quality Loss Function, Taguchi Quality Philosophy- Robust Design Concept, Orthogonal Arrays, Total Productive Maintenance (TPM) - Concept, Improvement Needs, FMEA - Stages of FMEA, The seven tools of quality, Process capability, Concept of six sigma, New seven management tools, Case studies.

Quality Systems: Need for ISO 9000 and Other Quality Systems, ISO 9000:2000 Quality System - Elements, Implementation of Quality System, Documentation, Quality Auditing, QS 9000, ISO 14000 - Concept, Requirements and Benefits, Case Studies

Reading:

1. Dale H. Besterfiled, “Total Quality Management”, Pearson Education, Delhi, 2006.
2. Subburaj Ramasamy, “Total Quality Management”, Tata McGraw Hill Publishing Company Ltd.,New Delhi, 2005.
3. Narayana V and Sreenivasan N.S., “Quality Management - Concepts and Tasks”, New Age International, Delhi, 1996.

Department Elective 4

ME421	**MICRO-SCALE HEAT TRANSFER**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-Requisites: CE236: Fluid mechanics and Hydraulic Machines, ME352: Heat and Mass Transfer

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

CO1	Apply scaling laws for heat transfer and flow phenomenon.
CO2	Analyze surface tension dominated flows.
CO3	Analyze systems with micro-scale heat conduction and micro-scale heat convection.
CO4	Apply microfabrication techniques for the manufacture of micro-scale systems.
CO5	Identify techniques for measuring micro-scale flow and heat transfer

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	3	2	1	-	-	-	-	-	-	2	2	2
CO2	3	3	3	2	1	-	-	-	-	-	-	2	2	2
CO3	3	3	3	2	1	-	-	-	-	-	-	2	2	2
CO4	3	3	3	3	2	-	-	-	-	-	-	2	2	2
CO5	3	3	3	3	2	-	-	-	-	-	-	2	2	2

Detailed Syllabus:

Introduction: Historical Perspectives, Definition, Biological Systems, Analogy with computational platforms, Benefits, Application Examples: Micro Electro-Mechanical Systems (MEMS), Lab on a Chip, Micro reactor, Micro heat pipes, Micro sensors, Micro actuators, Micro Pumps, Drug delivery systems.

Scaling Analysis: Natural systems, Parallel plate capacitor for sensor, Micro droplets, Micro resonator, Micro reactor, Micro heat exchangers

Channel Flow: N-S equations, Dimensional Analysis, Hydraulic resistance, arbitrary shaped channel flow, Elliptic, Equilateral and Rectangular channel flow, Dissipation effect, Complianceof channel wall.

Transport Laws: Boundary slip, Momentum accommodation coefficient, Thermal accommodation coefficient, Thermal creep, Knudsen Compressor, Slip flow boundary condition in liquids and gases, Physical parameters affecting Slip, Slip Model Derivation, Compressibility effect, Slip flow between parallel plates and Couette flow, Introduction to molecular modeling, Deterministic molecular modeling, Statistical molecular modeling, Boltzmann Equation, Direct Simulation Monte-Carlo (DSMC) Method.

Diffusion, Dispersion and Mixing: Random walk model of diffusion, Stokes-Einstein Law, Fick's law, governing equation of multicomponent system, Characteristic non-dimensional parameters, fixed planar source diffusion, Constant planar source diffusion, Convection- diffusion equation, Taylor dispersion, Micromixer examples, Soluble or rapidly reacting wall, Reverse osmosis channel flow.

Surface Tension Dominated Flows: Microscopic model of surface tension, Gibbs free energy, Young-Laplace equation, contact angle (Static and Dynamic), Wetting, Super hydrophobicity and hydrophilicity, Coating flows, Thermo-capillary flows, Thermo capillary pump, Diffuso- capillary flows, Electro-wetting, Taylor flows, Two-phase liquid flows, Clogging pressure, Digital microfluidics, Marangoni convection and instability.

Microscale Heat Conduction: Energy Carriers, Time and length scales, Scale effects, Fourier's law, Hyperbolic heat conduction, Kinetic theory, Electron thermal conductivity in metals, Lattice thermal conductivity, Scale effects of thermal conductivity, Boltzmann transport theory, Heat transport in thin films and at solid-solid interfaces, Heat conduction in semiconductor devices and interconnects, Laser heating.

Microscale Convection: Scaling laws, Temperature jump boundary condition, Convection in parallel plate channel flow and Couette flow with and without viscous dissipation, Similarity and dimensionless parameters, Flow boiling in micro channels, Mini-channel versus micro-channel, Nucleate and convective boiling, Dryout incipience quality, Saturated and sub-cooled flow boiling, Condensation heat transfer in mini-micro channels, Micro heat pipes.

Micro Fabrication: Functional materials, Lithography, Subtractive technique, Etching, Wet etching, Dry etching, Deep reactive ion etching, Additive techniques, Physical vapor deposition, Chemical vapor deposition, PDMS based molding, Bonding, Laser micro fabrication technique.

Measurements: Micro scale velocimetry, Microscale thermometry.

Reading:

1. P. Tabeling “Introduction to Microfluidics”, Oxford University Press, 2005.
2. G. Karniadakis, A. Beskok and N. Aluru, “Microflows&Nanoflows: Fundamental and Simulation”, Springer Publication, 2005.
3. J. Berthier and P. Silberzan, “Microfluidics for Biotechnology”, Artech House, 2006.
4. H. Bruus, “Theoretical Microfluidics”, Oxford University Press, 2008.
5. N.T. Nguyen and S.T. Wereley, “Fundamentals and Applications of Microfluidics”, 2nd edition, Artech House, 2006.

ME422	**POWER PLANT ENGINEERING**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-Requisites:ME201: Engineering Thermodynamics

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

CO1	Understand functions of the components of power plant.
CO2	Understand the working of nuclear, thermal and gas-based power plants.
CO3	Evaluate the design layout and working of hydroelectric power plants.
CO4	Evaluate economic feasibility and its implications on power generating units.

Course Articulation Matrix:

PO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	-	2	1	-	-	-	-	2	2	2
CO2	3	3	3	2	-	2	1	-	-	-	-	2	2	2
CO3	3	3	3	2	-	2	1	-	-	-	-	2	2	2
CO4	3	3	3	3	-	1	1	-	-	-	2	2	2	2

Detailed Syllabus:

Analysis of Steam Cycles: Introduction to the course, Power plant layout and essential feature Rankine cycle, Reheating and regeneration, Problems on Rankine Cycle, Combined cycle power generation, Binary vapour cycles.

Fuels and Combustion: Basics on fuels and combustion, Mass and energy balance of steam generator, Draught system, Enthalpy of combustion.

Steam generators, accessories, and Condensers: Different types of boilers, description, working procedures, High pressure Boilers, Accessories, fluidized bed boiler. Direct Contact Condenser Surface Condensers, Effect of various parameters on condenser performance, Design of condensers, cooling towers and cooling ponds.

Hydroelectric power plant: Introduction, Hydrological Cycle and hydrographs, Design construction and operation.

Nuclear power plants: Introduction, concepts of nuclear fusion and nuclear fission, types of reactors and their operation.

Energy storage: Need of storage, types of energy storage, options and limitations.

Non-conventional power generation: Basics of different non-conventional power generation types, operation, limitations.

Power plant economics and other issues: Load duration curves, Power plant economics, estimation of tariff. Diesel and gas plants, Pollution and control, Greenhouse effect and control, Peak load plants.

Reading:

1. Arora & Dom kundwar, “Power plant engineering”, Dhanpat Rai & Sons, New Delhi, 2008.
2. M.M Ei-Wakil, “Power plant Technology”, McGraw Hill Com., 1985.
3. P C Sharma, “Power plant engineering”, S.K. Kataria & Sons, New Delhi, 2010.

ME423	**FUELS AND COMBUSTION**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-Requisites:ME201: Engineering Thermodynamics

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

CO1	Understand the concepts of combustion phenomena in energy conversion devices.
CO2	Apply the knowledge of adiabatic flame temperature in the design of combustion devices.
CO3	Identify the phenomenon of flame stabilization in laminar and turbulent flames.
CO4	Analyze the pollution formation mechanisms in combustion of solid, liquid and gaseous fuels.

Course Articulation Matrix:

PO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	-	-	-	-	-	-	-	2	2	2
CO2	2	2	2	2	-	-	-	-	-	-	-	1	1	1
CO3	3	3	3	2	-	-	-	-	-	-	-	1	2	2
CO4	3	3	2	2	-	-	-	-	-	-	-	2	2	2

Detailed Syllabus:

Introduction: Overview of the course-Thermo chemistry of combustion-Concept of Adiabatic Flame Temperature-Numerical Problems

Chemical Kinetics: Differences between equilibrium and rate-controlled reactions-Global versus Elementary Reactions. Elementary reaction rates, bimolecular reactions and collision theory, other elementary reactions, Relation between rate coefficients and equilibrium constants, Steady-state Approximation. The mechanism for Uni-molecular reactions, Chain and Chain-Branching reactions.

Introduction to species Mass Transfer: Rudiments of Mass Transfer, Mass Transfer Rate Laws, Species Conservation. The Stefan Problem, Liquid-vapor interface boundary conditions, Droplet evaporation, Numerical.

Simplified Conservation Equations for Reacting Flows: Overview-Overall Mass Conservation (Continuity) Species mass Conservation (Species Continuity) Momentum Conservation,1-D and

2-D forms, Energy Conservation-General 1-D Form, Shvab- Zeldovich Forms, Definition of Mixture Fraction.

Laminar Premixed Flames: Physical Description, Definition, Principal characteristics, Typical Laboratory Flames. Simplified Analysis, Assumptions, Conservation Laws, Solution, Factors Influencing flame velocity and Thickness: temperature, pressure, Equivalence ratio, fuel type, Flame speed Correlations for Selected fuels, Quenching, Flammability, and Ignition Flame lift-off (Blow-off) and flash back, Concept of Flame stretch-Karlovitz number, Flame Stabilization.

Introduction to Turbulent Flames: Turbulent length and time scales, Weak turbulent flames. Wrinkled Reaction Sheets, Distributed Reaction zones.

Pollutant Emissions: Effects of emissions, Quantification of Emissions, Emission Indices, Corrected concentrations, Various Specific emission measures-Emissions from Premixed Combustion: Oxides of Nitrogen, Carbon Monoxide, Unburned Hydrocarbons, Catalytic After- treatment, Particulate Matter. Emissions from non-Premixed Combustion: Oxides of Nitrogen, Unburned Hydrocarbons and Carbon Monoxide, Particulate Matter and Oxides of Sulfur, Numerical Problems.

Reading:

1. Stephen, R. Turns., Combustion, McGraw Hill, 2005.
2. Mishra, D.P., Introduction to Combustion, Prentice Hall, 2009.
3. Sharma, S. P., Fuels and Combustion, Tata McGraw Hill, New Delhi, 2001.
4. Heywood Internal Combustion Engine Fundamentals, McGraw Hill Co.1988
5. Warnatz, Ulrich Maas and Robert W. Dibble Combustion: Physical and Chemical Fundamentals, Modelling and Simulation, Experiments, Pollutant Formation, 1999.

ME424	**ADDITIVE MANUFACTURING**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: ME203: Production Processes and Management

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

CO1	Understand the working principle and process parameters of AM processes
CO2	Apply the suitable process for fabricating a given product
CO3	Use suitable post processes based on product application
CO4	Explore the applications of AM processes in various fields

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	2	-	-	2	-	-	-	-	-	-	-	3	2
CO2	2	3	-	-	2	-	-	-	-	-	-	-	3	2
CO3	2	2	-	-	2	3	-	-	-	-	-	-	3	2
CO4	2	3	-	-	2	3	-	-	3	-	-	3	3	2

Detailed syllabus:

Introduction to Additive Manufacturing (AM): Need for Additive Manufacturing, Generic AM process, Distinction between AM and CNC, Classification of AM Processes, Steps in AM process, Advantages of AM, Major Applications.

Vat Photopolymerization AM Processes: Stereolithography (SL), Materials, SL resin curing process, Micro-stereolithography, Process Benefits and Drawbacks, Applications ofPhotopolymerization Processes.

Material Jetting AM Processes: Evolution of Printing as an Additive Manufacturing Process, Materials, Process Benefits and Drawbacks, Applications of Material Jetting Processes.

Binder Jetting AM Processes: Materials, Process Benefits and Drawbacks, Research achievements in printing deposition, Technical challenges in printing, Applications of Binder Jetting Processes.

Extrusion-Based AM Processes: Fused Deposition Modelling (FDM), Principles, Materials, Plotting and path control, Bio-Extrusion, Process Benefits and Drawbacks, Applications of Extrusion-Based Processes.

Sheet Lamination AM Processes: Materials, Laminated Object Manufacturing (LOM), Ultrasonic Consolidation (UC), Gluing, Thermal bonding, LOM, and UC applications.

Powder Bed Fusion AM Processes: Selective laser Sintering (SLS), Materials, Powder fusion mechanism, SLS Metal and ceramic part creation, Electron Beam melting (EBM), Process Benefits and Drawbacks, Applications of Powder Bed Fusion Processes.

Directed Energy Deposition AM Processes: Process Description, Laser Engineered Net Shaping (LENS), Direct Metal Deposition (DMD), Electron Beam Based Metal Deposition, Benefits and drawbacks, Applications of Directed Energy Deposition Processes.

Post Processing of AM Parts: Support Material Removal, Surface Texture Improvement, Accuracy Improvement, Aesthetic Improvement, Preparation for use as a Pattern, Property Enhancements using Non-thermal and Thermal Techniques

AM Applications: Functional models, Pattern for investment and vacuum casting, medical models, art models, Engineering analysis models, Rapid tooling, new materials development, Bi-metallic parts, Re-manufacturing. Application examples for Aerospace, defense, automobile, Bio-medical and general engineering industries.

Reading:

1. Ian Gibson, David W Rosen, Brent Stucker, “Additive Manufacturing Technologies: 3DPrinting, Rapid Prototyping, and Direct Digital Manufacturing”, 2nd Edition, Springer, 2015.
2. Chua Chee Kai, Leong Kah Fai, “3D Printing and Additive Manufacturing: Principles& Applications”, 4th Edition, World Scientific, 2015.
3. Ali K. Kamrani, EmandAbouel Nasr, “Rapid Prototyping: Theory & Practice”, Springer, 2006.
4. D.T. Pham, S.S. Dimov, “Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling”, Springer 2001.
5. RafiqNoorani, “Rapid Prototyping: Principles and Applications in Manufacturing”, John Wiley & Sons, 2006.

ME425	**INDUSTRIAL AUTOMATION**	**DEC**	**3-0-0**	**3 Credits**

Pre-requisites: Nil

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

CO1	Understand principles, strategies, and advantages of industrial automation.
CO2	Design material handling and material storage systems for an automated factory.
CO3	Devise automated shopfloor controls and part identification methods.
CO4	Outline the IoT Technologies used in a manufacturing plant and their role in Industry.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	-	-	2	-	-	-	2	-	-	-	2	2
CO2	3	2	3	3	2	-	-	-	2	-	-	-	2	2
CO3	3	2	-	3	2	-	-	-	2	-	-	-	2	2
CO4	3	2	-	-	2	-	-	-	2	-	-	-	2	2

Detailed syllabus:

Principles and Strategies of Automation: Power to Accomplish the Automated Process, program of Instruction, Control System, Advanced automation Functions: safety Monitoring, maintenance and repair Diagnostics, error Detection and Recovery, levels of automations, Merits and Demerits of automation.

Material Handling systems and Design: Introduction to Material Handling, Material Transport Equipment, analysis of Material Transport Systems, Storage Systems-Storage System Performance and Location Strategies, Conventional Storage Methods and Equipment, Automation Storage Systems, Engineering Analysis of Storage Systems.

Automatic identification methods: Overview of Automatic Identification Methods, Bar Code Technology, Radio Frequency Identification, Other AIDC Technologies.

Industrial control systems: Process Industries Vs Discrete Manufacturing Industries, Levels of Automation in the two industries, Variables and Parameters in the two industries. Continuous Vs Discrete control- Continuous Control System, Discrete Control System. Control system components-Sensors, Actuators, Analog-to-Digital Convertors, Digital-to-Analog Convertors, Input/output Devices for Discrete Data.

Industry 4.0: Introduction, IoT Techniques, Cloud computing, machine learning, Digital Twin.

Reading:

1. Groover M. P., “Automation production Systems and Computer Integrated Manufacturing”, Pearson Education, 2013.
2. Krishna Kant, “Computer Based Industrial Control”, Prentice Hall of India, New Delhi, 2010.
3. Tiess Chiu Chang and Richard A. W., “An Introduction to Automated Process Planning Systems”, Tata McGraw-Hill Publishing Company, New Delhi, 2012.
4. Klafter, R.D., Chmielewski, T. A. and Negin M., “Robot Engineering-An Integrated Approach”, Prentice Hall of India, New Delhi, 2012.
5. Craig J. J., “Introduction to Robotics Mechanics and Control”, 3rd Edition, Pearson Higher Education, 2014.

ME426	**ADVANCED MATERIALS PROCESSING**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: ME203: Production Processes and Management

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

CO1	Understand the different processing techniques for engineering materials.
CO2	Analyze the principles of casting for the manufacturing of MMC.
CO3	Utilize appropriate manufacturing methods for powder metallurgical components.
CO4	Apply laser for processing of engineering materials.
CO5	Analyze the processing of ceramics.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	3	2	2	2	-	-	-	-	-	-	2	2
CO2	3	3	3	2	2	2	-	-	-	-	-	-	3	3
CO3	3	3	3	2	2	2	-	-	-	-	-	-	2	2
CO4	3	3	3	2	2	2	-	-	-	-	-	-	2	3
CO5	3	2	2	2	2	2	-	-	-	-	-	-	2	2

Detailed Syllabus:

Processing of Metallic materials: Introduction to solidification process, single crystal and poly crystalline materials, grain growth, temperature distribution during solidification process, Zone refining, Effect of inoculation in casting of various materials, Production of MMC through stir casting and centrifugal casting processes and its characterization, advantages, limitations, and applications.

Powder Metallurgy techniques in processing of materials: Introduction to powder metallurgy, various processes in powder metallurgy, Production of composites.

Ceramics: Classification of ceramics, Applications, fabrication and Processing of ceramics, Rheological behavior of composites, Characterization of composites before and after processing.

Laser processing of materials: Laser hardening, laser heat treatment, and laser forming

Forming of metals, plastics and ceramics: Hot and cold Processing, Forming of glass, forming of ceramics, Processing of polymers, Defective analysis of formed glass, ceramics and polymers, Characterization of composites before and after processing.

Reading:

1. Michel Ashby, "Materials Engineering Science Processing and Design", Butterworth-Heinemann, 2017.
2. Y. Waseda, A. Muramatsu and Yoshio Waseda, "Morphology Control of Materials and Nanoparticles: Advanced Materials Processing and Characterization", Springer, 2014.

ME427	ROTOR DYNAMICS	DEC	3-0-0	3 credits

Pre-Requisites: ME251: Dynamics of Machinery

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

CO1	Model the Rotor bearing systems and formulate the governing equations.
CO2	Understand the role of damping, gyroscopic, centrifugal, stiffness and inertial effects on rotors.
CO3	Compute the critical speeds and stability limits for rotors under axial, transverse and torsional modes.
CO4	Analyse the rotor bearing systems using transfer matrix method and Finite Element Method.
CO5	Compute the transient response of rotors.

Course Articulation Matrix:

PO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	2	-	-	-	-	-	-	2	3	2
CO2	3	3	1	-	-	-	-	-	-	-	-	2	2	1
CO3	3	2	2	-	2	-	-	-	-	-	-	2	3	2
CO4	2	2	2	-	1	-	-	-	-	-	-	2	3	3
CO5	1	-	2	-	2	-	-	-	-	-	-	2	3	3

Detailed Syllabus:

Introduction: Introduction to rotor dynamics & smart rotor systems, Review of momentum principles, Hamilton's principle, and Lagrange's equations, Rotating and reciprocating unbalances, Classification of Discrete and continuous systems, Review of free and forced vibrations of single and multi-degree of freedom systems.

Linear Rotor Dynamics: Equation of motion, Rotating systems, Complex coordinate representation, Undamped Jeffcott Rotor - Free whirling, Unbalance response, Shaft Bow Jeffcott Rotor with viscous damping - Free whirling, Unbalance response, Shaft Bow With structural damping - Free whirling, Unbalance response, frequency dependent loss factors with non-synchronous damping, Effect of Bearing Compliance, Stability in supercritical region.

Modelling with Four Degrees of Freedom:

Generalized coordinates and equations of motion in real and complex coordinates, Static and couple unbalance and their effects, uncoupled gyroscopic systems, Free whirling of coupled undamped systems, Unbalance response and Shaft bow. Model uncoupling of gyroscopic systems, Configuration, and state space approaches. Disc gyroscopic, synchronous, and nonsynchronous whirl, forward and backward whirl.

Discrete multi-degree of freedom:

Introduction, Transfer matrix approach for undamped systems, Damped systems, the finite element method for rotors, Beam elements, spring elements, Mass elements, Assembly and constraints, damping matrices, Choice of coordinates: fixed Vs Rotating and Real Vs Complex coordinates, Computation of critical speeds, Computation of unbalance response. Campbell and root locus diagrams, Reduction of DOF: Nodal reduction, model reduction and component mode synthesis.

Transmission Shafts: Modelling of rotors as continuous systems, Euler-Bernoulli and Timoshenko beam models, Dynamic stiffness, Analytical and approximate solutions.

Anisotropy of rotors and supports:

Isotropic rotors on Anisotropic supports - Influence of damping, non-isotropic rotors on isotropic supports.

Torsional and Axial Dynamics:

Free and forced Torsional vibrations and critical speeds, Axial Vibration of rotors

Rotor-Bearing Interaction:

Rigid body and flexural modes, Linearization of bearing Characteristics, Rolling element bearings, Fluid film bearings, Magnetic bearings, bearing alignment in multi rotor bearings

Reading:

1. Giancarlo Genta, Dynamics of Rotating Systems, Springer, 2009
2. Rao, J.S., Rotor Dynamics, 3 Ed. New Age International, 2003
3. Maurice L. Adams, Jr., Rotating Machinery Vibrations, Marcel Dekker, Inc., New York, 2001
4. Chong-Won Lee, Vibration Analysis of Rotors, Kluwer Academic Publishers, London, 1995
5. Muszynska A, Rotor dynamics, Taylor & Francis, New York, 2005

ME428	**ENGINEERING ACOUSTICS**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: Nil

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

CO1	Understand wave propagation, absorption, transmission, reflection and radiation.
CO2	Formulate acoustic problems for reduction of sound levels.
CO3	Analyze and design resonant systems including pipes, mufflers, Helmholtz resonators.
CO4	Evaluate architectural acoustics reverberation time, direct echoes and acoustical amplification.
CO5	Analyze the acoustic levels and analytical predictions.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	-	1	-	-	-	-	-	-	-	2	2	1
CO2	3	3	3	1	1	-	-	-	-	-	-	1	3	2
CO3	2	2	2	2	2	-	-	-	-	-	-	2	3	2
CO4	2	1	1	2	-	-	-	-	-	-	-		3	3
CO5	2	2	2	2	1	-	-	-	-	-	-	1	3	2

Detailed Syllabus:

Introduction: Review of vibrations, resonance and frequency, Sound pressure, power and intensity and its measurement, Concept of Monopoles, Dipoles and Quadrupoles, Sound Power measurement, Transmission loss, Longitudinal and Transverse wave equations, Spherical and cylindrical wave equation, Acoustic intensity, decibel scales, Sound wave generators.

Acoustic wave propagation: Transmission/reflection of waves in different media, radiation and reception of acoustic waves, absorption and attenuation of sound, Cavities and waveguides. Wave types in fluids and solids. Modes of vibrations in solids.

Pipes, Resonators, and Filters: Resonance in pipes, standing waves, Absorption of sound, Helmholtz resonator, acoustic impedance, acoustic filters.

Damping Attenuation and Absorption: Viscous attenuation of sound, absorption by atmosphere, attenuation in water, absorption in fluid filled pipes, damping in solids.

Architectural Acoustics: Sound in enclosures, direct and reverberant sounds, sound absorption materials, acoustic factors in architectural design, standing waves and normal modes in enclosures.

Noise Control: The auditory system, Effects of noise on humans, noise measurement and criterion, treatment at source and treatment of transmission path, Analysis and design of mufflers for automotive applications, Noise measurement and instrumentation standards. Noise Control approaches.

Reading:

1. Robert D Finch. Introduction to acoustics, PHI2008
2. Michael Moser, Michael Maser, S. Zimmermann, Engineering Acoustics: An introduction to Noise Control, 2/e, Springer, 2009.
3. Frank J Fahy, Foundations of Engineering Acoustics, Academic Press, 2000.
4. Michael Moeser, Michael Maser, Engineering Acoustics: An Introduction to Noise Control, Springer, 2004.

ME429	**MECHANICS OF COMPOSITE MATERIALS**	**DEC**	**3-0-0**	**3 Credits**

Pre Requisite: MM235; Materials Engineering

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

CO1	Understand the industrial need for composite materials.
CO2	Identify suitable processes to develop fiber reinforced composite materials.
CO3	Apply the micro and macro mechanics for fiber reinforced composite materials.
CO4	Develop governing equation for Bending, Buckling, and Vibration of Laminated plates.
CO5	Design the composite structures with the help of computers.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	-	2	-	-	-	2	3	2	-	3	-	2	-	2
CO2	-	2	3	3	3	2	3	2	-	3	-	2	-	-
CO3	3	3	-	-	-	-	-	2	-	-	-	2	3	2
CO4	3	3	-	-	-	-	-	2	-	-	-	2	3	-
CO5	-	-	3	-	3	-	3	2	-	-	-	2	3	3

Detailed Syllabus:

Introduction to composite materials: Introduction, what is a composite material, Current and potential advantages of fibre reinforced composites, Applications of composite materials, Military, civil, space, automotive and commercial applications

Macro and micro mechanical behavior of a lamina: Stress strain relations for anisotropic materials, Restrictions on engineering constants, Strengths of an orthotropic lamina, biaxial strength criteria for orthotropic lamina

Micro mechanical behavior of lamina and laminates: Mechanical of material approach to stiffness, Elasticity approach to stiffness, Classification lamination theory, Special cases, strength of laminates

Bending, Buckling and Vibration of laminated plates: Governing equations for bending buckling and vibration of laminated plates, Deflection of simply supported laminated plates, Vibration of simply supported laminated plates

Design of composite structures: Introduction, design philosophy, Anisotropic analysis, bending extension coupling, Micromechanics, Nonlinear behavior, Inter-laminar stresses, transverse shearing, Laminate optimization

Reading:

1. Ronald F. Gibson, Principles of composite material mechanics, CRC Press, 2011.
2. Robert M Jones, Mechanics of Composite Materials, Taylor & Francis, 2000.
3. Lawrence E. Nielsen, Nielson, Paul Nielsen, Mechanical Properties of Polymers and Composites, Second Edition, CRC press, 2000.

ME430	**OPERATIONS RESEARCH**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: Nil

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

CO1	Understand the concepts of operations research modelling approaches.
CO2	Formulate engineering and managerial situations as LPP, transportation and Assignment problems.
CO3	Solve LPP, Transportation and Assignment problems
CO4	Formulate multi-stage applications into a dynamic programming framework.
CO5	Solve Integer programming problems.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	-	-	-	-	-	-	-	-	-	-	2	3	2
CO2	3	3	2	-	-	-	-	-	-	-	2	2	3	3
CO3	3	3	3	2	2	2	-	-	-	-	2	2	3	2
CO4	3	3	2	-	2	-	-	-	-	2	3	2	3	2
CO5	3	2	2	-	2	-	-	-	-	2	2	2	3	2

Detailed syllabus:

Introduction: Historical overview of operations research, fundamentals of OR Modelling Approach.

Linear Programming: Basic assumptions, formulation, graphical method, simplex method, dualitytheory, primal-dual relationships, sensitivity analysis.

Transportation and Assignment Problems: Specific features of transportation problem, streamlined simplex method for solving transportation problems, special features of assignment problems, Hungarian method for solving assignment problems.

Dynamic Programming: Characteristics, principle of optimality, solution procedure, deterministicproblems.

Integer programming: Special features, binary integer programming models, branch-and-boundtechnique, cutting-plane method, introduction to nonlinear programming.

Reading:

1. Taha H. A, “Operations Research”, 10thEdition, Prentice Hall of India, New Delhi, 2017.
2. Hillier F.S.and Lieberman G.J., “Introduction to Operations Research”, 7th Edition, TMH, 2009.

Departmental Electives 5

ME461	Alternate Fuels and Energy Systems	DEC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

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

CO1	Understand the need for Alternative fuels, and their availability.
CO2	Analyze the combustion and emission characteristics of IC engine running on fuel blends.
CO3	Broad comprehension of types alternative fuels like Jatropha, Pongamia, Rice bran, Mahuaetc, CNG, LPG etc and their usage in IC engines.
CO4	Identify advantage and limitations, specifications, of solar powered hybrid vehicles.
CO5	Classify the emissions and can evaluate the vehicle emissions based on EURO and Indian Emission norms.

Course Articulation Matrix:

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	-	-	2	-	1	-	-	2	-	-	3	1
CO2	2	-	2	-	2	-	1	-	-	1	-	-	3	3
CO3	2	-	3	-	3	-	2	-	-	2	-	-	2	2
CO4	3	-	1	-	1	-	2	-	-	3	-	-	2	3
CO5	1	-	-	-	1	-	3	-	-	1	-	-	1	2

Detailed syllabus:

SYLLABUS: PV Cells,

Unit-I Introduction: Estimation of petroleum reserve – Need for alternate fuels – Availability and properties of alternate fuels, ASTM standards

Unit-II Alcohols: General Use of Alcohols – Properties as Engine fuel – Gasolene and alcohol blends – Performance in SI Engine – Methanol and Gasolene blend – Combustion Characterstics in engine – emission characteristics

Unit-III Vegetable oils: Soyabeen Oil, Jatropha, Pongamia, Rice bran, Mahuaetc as alternate fuel and their properties, Esterification of oils

Natural Gas, LPG: Availability of CNG, properties, modification required to use in engines – performance and emission characteristics of CNG using LPG in SI & CI engines.

Hydrogen: Hydrogen production, Hydrogen as an alternative fuel, fuel cell

Unit-IV Electric and Solar powered vehicles: Layout of an electric vehicle – advantage and limitations-specifications –system component – electronic control system – High energy and power density batteries – Hybrid vehicle – solar powered vehicles

Unit-V Automobile emissions & its control: Need for emission control -Classification/ categories of emissions -Major pollutants - control of emission.ns – Evaluating vehicle emissions – EURO I,II,III,IV standards – Indian standards

Text Books/ References:

1. Richard, L. (1997). Alternative Fuels Guidebook Properties, Storage, Dispensing and Vehicle Facility Modifications. Society of Automotive Engineers (SAE), 1-721.

2. Norbeck, J. M., Heffel, J. W., Durbin, T. D., Tabbara, B., Bowden, J. M., & Montano, M. C. (1996). Hydrogen fuel for surface transportation (Vol. 160).

3. Wakefield, E. H. (1998). History of the Electric Automobile-Hybrid Electric Vehicles (Vol. 187)

4. Pundir, B. P. (2007). Engine emissions: pollutant formation and advances in control technology. Alpha Science International, Limited.

5. S.C. Bhatia (2007) Air Pollution and its Control, Atlantic Publications,

6. Halderman, J. D., & Linder, J. (2011). Automotive fuel and emissions control systems. Pearson Higher Ed.

ME462	**Radiation Heat Transfer**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: Nil

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

CO1	Understand the surface radiation characteristics, reflexivity, transmissivity, spectral and directional variation.
CO2	Analyze the radiation exchange between different surfaces understand their applications
CO3	Understand the gas radiation, optical limits and Radiation heat transfer during flow over flat plate.
CO4	Understand the concepts of scattering, radiative equilibrium with scattering and different methods of scattering.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	-	-	3	-	-	2	-	2	-	3	-	2	1
CO2	3	-	-	1	-	-	2	-	1	-	2	-	2	2
CO3	2	-	-	1	-	-	1	-	1	-	1	-	3	2
CO4	1	-	-	2	-	-	-	-	1	-	-	-	1	-

Detailed syllabus:

Unit I Radiation Heat Transfer: Properties and Processes, Introduction, Nature of Thermal Radiation, Radiation Definitions, Surface Characteristics: Absorptivity, Reflectivity and Transmissivity, Black-Body Radiation, Laws of Black-Body Radiation, Intensity of Radiation, Lambert's Cosine Law, Kirchhoff's Law, Radiation from Real Surfaces, Solar and Environmental Radiation, Spectral and directional variations

Unit II Radiation exchange between surfaces

Shape factor, Triangular enclosure, Evaluation of shape factors, Radiation in enclosures, Electrical analogy, Applications, Non-gray enclosures, Enclosure with Specular surfaces, Integral method for enclosures

Unit III Gas Radiation: Introduction to gas radiation, Plane parallel model, Diffusion approximation, Radiative equilibrium, optically thick limit, Radiation spectroscopy, Isothermal gas emissivity, Band models, Total Emissivity method, Isothermal gas enclosures, Well-stirred furnace model, Gas radiation in complex enclosures, Interaction between radiation and other modes of heat transfer, Radiation heat transfer during flow over flat plate

Unit IV Scattering : Radiation and Climate, Radiative-convective equilibrium, Radiative equilibrium with scattering, Radiation measurement, Radiation with internal heat source, Particle scattering, Scattering in the atmosphere, non-isotropic scattering, Approximate methods in scattering: 1, Approximate methods in scattering: 2, Monte Carlo method

References:

1. Heat and Mass Transfer by DK Dixit, McGraw Hill Education, 2016
2. Siegel, R. and Howell, J., Thermal Radiation Heat Transfer, Taylor and Francis 2002.
   Cengel Y., Ghajar A., Heat and Mass Transfer, McGraw Hill.
3. Incropera F., DeWitt D. Fundamentals of Heat and Mass Transfer, John Wiley.
4. Sukhatme S.P., Heat Transfer, Universities Press.
5. Holman J. P., Heat and Mass Transfer, McGraw Hill.
6. Kumar D. S., Heat and Mass Transfer, Kataria and Sons.
7. Nellis G.,Klein S., Heat Transfer, Cambridge University Press
8. Incropera, F.P., and DeWitt, D.P., Fundamentals of Heat and Mass Transfer, 7th Ed.,Wiley

ME463	**RELIABILITY ENGINEERING**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: Nil.

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

CO1	Understand the concepts of reliability, availability, and maintainability
CO2	Develop hazard-rate models to know the behavior of components
CO3	Build system reliability models for different configurations
CO4	Assess reliability of components and systems using field and test data
CO5	Implement strategies for improving reliability of repairable and non-repairable systems

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	-	-	-	-	-	-	-	-	3	3	-	3	-
CO2	3	-	3	-	-	3	3	2	3	-	-	-	2	-
CO3	3	3	3	2	-	3	3	3	3	-	-	3	2	-
CO4	3	2	2	3	-	3	3	2	2	-	-	-	2	-
CO5	3	3	-	3	-	2	3	2	-	-	-	-	3	-

Detailed syllabus:

Introduction: Probabilistic reliability, failures and failure modes, repairable and non-repairable items, pattern of failures with time, reliability economics.

Component Reliability Models: Basics of probability & statistics, hazard rate & failure rate, constant hazard rate model, increasing hazard rate models, decreasing hazard rate model, time-dependent & stress-dependent hazard models, bath-tub curve.

System Reliability Models: Systems with components in series, systems with parallel components, combined series-parallel systems, k-out-of-m systems, standby models, load- sharing models, stress-strength models, reliability block diagram.

Life Testing & Reliability Assessment: Censored and uncensored field data, burn-in testing, acceptance testing, accelerated testing, identifying failure distributions & estimation of parameters, reliability assessment of components and systems.

Reliability Analysis & Allocation: Reliability specification and allocation, failure modes and effects and criticality analysis (FMECA), fault tree analysis, cut sets & tie sets approaches; Maintainability Analysis: Repair time distribution, MTBF, MTTR, availability, maintainability, preventive maintenance.

Reading:

1. Ebeling C. E. “An Introduction to Reliability and Maintainability Engineering”, TMH, New Delhi, 2004.
2. O’Connor P and Kleymer A, “Practical Reliability Engineering”, Wiley, 2012.

ME464	**Product Life Cycle Management**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: Nil

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

CO1	Understand product data, information, structures and PLM concepts.
CO2	Apply PLM systems in organization verticals including production, after sales, sales and marketing, and subcontracting.
CO3	Measure benefits of PLM implementation in daily operations, material costs, productivity of labour and quality costs.
CO4	Apply PLM concepts for service industry and E-Business.
CO5	Recognize tools and standards in PLM.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	-	-	-	2	-	-	-	-	2	2	2	2
CO2	3	2	-	-	-	3	2	-	3	-	3	2	2	2
CO3	3	2	-	-	-	3	2	-	-	-	2	2	2	2
CO4	3	2	-	-	3	3	2	-	-	-	2	2	2	2
CO5	3	2	-	-	-	2	-	-	-	-	2	2	2	2

Detailed syllabus:

DETAILED SYLLABUS:

Fundamentals of PLM: Product data or Product information, Product lifecycle management concept, Information models and product structures-Information model, The product information (data) model, The product model, Reasons for the deployment of PLM systems.

Enterprise solution with PLM: Use of product lifecycle management systems in different organization verticals, Product development and engineering, Impact of Manufacturing with PLM-Challenges of product management in the engineering and manufacturing industry, Life cycle thinking, value added services and after sales, Case 1: Electronics manufacturer, Case 2: An engineering product.

Product Structures: Standardized product data and materials data model, Product structure of a ship, Product structure of a customizable product, Product structure of a configurable service product.

PLM service information model: Categorizing services, Rational for building service products, how to make a service more like a tangible product, Making items out of product functions, PLM challenges in service business, An IT-service provider, and a customer-specifically variable product.

PLM for e-manufacturing: electronic business and PLM, Preconditions for electric business from the viewpoint of the individual company, Significance of product management, collaboration, and electronic business for the manufacturing industry.

Integration of the PLM system with other applications: Different ways to integrate PLM systems, Transfer file, Database integration, System roles, ERP, Optimization of ERP for PLM, and CAD.

Implementing end to end business process management: Product lifecycle management as a business strategy tool, Product lifecycle management as an enabler of cooperation between companies, Contents of collaboration, Successful cooperation, Tools of collaboration, From changes in the business environment to product strategy, Business Benefits of PLM.

PLM applications in process and product industries examples: Case 1: Electronics manufacturer, Case 2: An engineering product, Case 3: Capital goods manufacturer and customer-specifically variable product, Case 4: An IT-service provider and a customer-specifically variable product.

READING:

1. Jaya Krishna S, *Product Lifecycle Management: Concepts and cases,* ICFAI Publications 2011.
2. *SOA approach to Enterprise Integration for Product Lifecycle,* IBM Red books, 2011.

ME465	**FLEXIBLE MANUFACTURING SYSTEMS**	**DEC**	3 – 0 – 0	**3 Credits**

Pre-requisites: None.

Course Outcomes:	At the end of the course, the student will be able to:
CO1	Understand FMS and job-shop and mass production manufacturing systems.
CO2	Understand processing stations and material handling systems used in FMS environments.
CO3	Design and analyze FMS using simulation and analytical techniques.
CO4	Understand tool management in FMS.
CO5	Analyze the production management problems in planning, loading, scheduling, routing and breakdown in a typical FMS.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	2	2	-	2	1	-	-	-	-	2	1	3	2
CO2	3	2	1	2	2	1	-	-	-	-	2	1	3	3
CO3	2	3	3	-	2	1	-	-	-	-	1	1	3	2
CO4	2	2	1	2	3	1	-	-	-	-	1	1	3	2
CO5	2	2	1	-	2	1	-	-	-	-	1	1	3	2

Detailed Syllabus:

Understanding of FMS: Evolution of Manufacturing Systems, Definition, objective and Need, Components, Merits, Demerits and Applications of FMS

Processing stations: Machining Centers, turning centers, CMM, Washing/ Deburring station, etc. Different Layouts and their Salient features

Material Handling System: An introduction, Conveyor, AGV, ASRS, Robots, etc. and their salient features.

Management technology: Tool Management, Configuration planning and routing, Production Planning and Control, Scheduling and control

Computer networks and control: Hardware, Software, and database of FMS

Design of FMS: Performance Evaluation, Analytical model, and Simulation model of FMS

Case studies: Typical FMS problems from research papers

Reading:

1. Groover,M.P “Automation, Production Systems and Computer Integrated Manufacturing”, Prentice Hall of India Pvt.Ltd. New Delhi 2009

2. Tempelmeier.H and Kuhn.H. “Flexible Manufacturing system: Decision support for design and operation”, John Wiley and Sons 2003.

3. Maleki A. “Flexible Manufacturing Systems: the technology and management”. Prentice Hall International –2009

ME466	**LASER PROCESSING OF MATERIALS**	**DEC**	3 – 0 – 0	**3 Credits**

Pre-requisites: Nil

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

CO1	Demonstrate the importance of industrial lasers and laser processing.
CO2	Understand the laser material interactions and transport phenomena
CO3	Evaluate laser-based surface modification processes.
CO4	Demonstrate laser for different applications like metal forming, cutting, drilling, marking etc.
CO5	Understand the principle of laser based Additive Manufacturing Process

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	2	2	-	2	2	-	-	-	-	2	2	-
CO2	3	3	2	2	-	2	3	-	-	-	-	2	2	2
CO3	3	3	2	2	-	2	3	-	-	-	-	2	2	2
CO4	3	3	2	2	-	2	2	-	-	-	-	2	2	2
CO5	3	3	2	2	-	2	2	-	-	-	-	2	2	2

Syllabus:

Basics of Lasers: Laser Operation Mechanism, Properties of Laser Radiation.

Introduction to industrial lasers: He-Ne, CO2, Excimer, Nd:YAG, Diode, Fiber and Ultra-short pulse lasers and their output beam characteristics; laser beam delivery systems.

Fundamentals of Laser Material Interactions: Absorption of Laser Radiation, Thermal Effects, Materials science for laser processing, Transport phenomena for laser materials processing.

Lasers in Manufacturing: Laser Cutting, Laser Drilling, Laser Machining, Laser Forming, Laser Welding, Laser Surface Alloying, Laser Cladding and their process characteristics.

Laser surface modifications: Heat treatment, surface remelting, surface alloying and cladding, surface texturing, LCVD and LPVD.

Ultra-short laser processes: pulse interaction, metallurgical considerations and micro fabrication.

Laser metal forming: Mechanisms involved including temperature gradient, buckling, upsetting. Laser peening: Laser Shock Processing.

Laser Additive Manufacturing: Classification, Processing Philosophy and Metallurgical

Mechanisms, Modeling of Laser Material Processing.

Text Books:

1. The Mathematics of Thermal Modeling: An Introduction to the Theory of Laser Material Processing” John Michael Dowden, Chapman and Hall/CRC, 2001.
2. Principles of Laser Materials Processing, E Kannatey-Asibu, Wiley, 2009.

References:

1. Laser Material Processing, 4th Edition, W M Steen and J Mazumder, Springer, 2010.

2. Laser Processing of Materials - Fundamentals, Applications and Developments, Schaaf, Peter , Springer, 2010.

3. Physics of Laser Materials Processing: Theory and Experiment, Gennady G.Gladush and Igor Smurov, Springer, 2011.

4. Laser Fabrication and Machining of Materials, N B Dahotre and S P Harimkar, Springer, 2008.

5. Laser Processing of Engineering Materials: Principles, Procedure and Industrial Applications, John C Ion, Elsevier, 2005.

ME467	**INNOVATIVE DESIGN**	**DEC**	**3-0-0**	**3 Credits**

Pre-requisites: Nil

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

CO1	Understand the conceptual development techniques to find solution for a critical design issue.
CO2	Apply embodiment principles to translate the conceptual ideas to engineering design.
CO3	Apply environmental, ethical, and social issues during innovative design process.
CO4	Design and develop innovative engineering products for industrial needs using robust design philosophy.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	-	-	2	-	3	2	2	2	-	-	-	2	1	3
CO2	-	-	2	-	3	2	2	2	-	-	-	2	1	3
CO3	-	-	-	-	3	3	3	3	-	-	-	2	1	3
CO4	-	-	2	-	3	3	2	3	3	-	-	2	1	3

Detailed Syllabus:

Introduction: Modern product development and design, State of art, Understanding the opportunity, Develop a concept, implement a concept, Reverse engineering and redesign methodology, Comparison between scientific method and design method.

Need Identification and Problem definition: Wheelwright Clark model, constructing a survey instrument, Kano diagram, Establishing Engineering Characteristics, Benchmarking, Evaluating Customer Requirements, Quality Function Deployment (QFD) and Product Design Specification (PDS).

Information Gathering: types, sources, Copy rights and Intellectual property systems, Journals and patent writing, Codes and Standards.

Concept generalization: Creativity and problem solving, Models of brain, Creative methods, and barriers, Theory of Inventive Problem Solving (TRIZ), Physical and Functional Decomposition, Morphological analysis, Axiomatic design.

Concept evaluation and decision making- Decision Theory, Evaluation methods, Pugh's concept, weighted decision matrix, Analytic hierarchy process (AHP)

Embodiment design: Phases, Significance, Product architecture, Configuration and Parametric design, detailed design, Design for X: Manufacturing, Assembly, Environment, Robustness

Ethical Issues and Team Management: Ethical issues during Engineering design process, Product liability, Tort law, functioning, discharge, Team Dynamics and problem-solving tools in design, Case studies.

Reading:

1. Engineering Design by George E Dieter
2. GenrichAltshuller, The Innovation Algorithm, Technical Innovation Centre, 2011.
3. Nigel Cross, Engineering Design Methods, John Wiley, 2009.

ME468	**THEORY OF CONSTRAINTS**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: Nil

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

CO1	Understand the philosophy of TOC.
CO2	Assess the system performance using throughput accounting.
CO3	Apply DBR and OPT methodologies for manufacturing scheduling.
CO4	Implement critical chain methodology for project scheduling
CO5	Understand TOC thinking process tools including CRT, EC, FRT and PRT

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	-	-	-	-	-	-	3	-	-	-	-	2	-
CO2	3	3	-	-	-	-	-	3	-	-	2	-	3	-
CO3	3	3	3	-	-	-	-	2	3	-	-	-	2	-
CO4	3	3	3	-	-	3	-	3	3	-	3	-	2	-
CO5	3	-	-	-	3	-	-	-	-	-	3	-	-	-

Detailed syllabus:

Introduction: Basic philosophy, local and global optima, five focusing steps of TOC, comparison with TQM & JIT philosophies.

Throughput Accounting: Financial and operating measures, local and global performance measures, throughput, inventory, operating expenses, linking concepts of throughput accounting with financial accounting.

Manufacturing Scheduling: Line and job shop processes, make-to-stock and make-to-order environments, scheduling rules, DBR methodology for scheduling line processes, OPT methodology for scheduling job shops, buffering and types of buffers, buffer management; **Project Scheduling**: Critical chain methodology, developing single-project critical chain plan, developing multi-project critical chain plan, buffer and threshold sizing, project risk management.

TOC Thinking Process: Current reality tree, evaporating clouds, future reality tree, Pre-requisite tree, transition tree.

Reading:

1. Dettmer H. W., "Goldratt's Theory of Constraints: A Systems Approach to Continuous Improvement", ASQ Quality Press, Wiscousin, 1997.
2. Leach L.P., "Critical Chain Project Management", 2nd Edition, Artech House Inc, London, 2005.

ME469	**ADVANCED OPERATIONS RESEARCH**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: Nil

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

CO1	Understand game, queuing and decision theories
CO2	Apply queuing theory for performance evaluation of engineering and management systems.
CO3	Simulate and analyze engineering and managerial problems
CO4	Solve optimization problems using evolutionary computing methods

Course Articulation Matrix:

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	-	-	2	-	-	-	2	2	3	2	2	2
CO2	3	3	3	-	2	2	2	-	2	2	3	2	3	2
CO3	3	3	2	-	3	-	-	-	2	2	3	2	2	3
CO4	3	3	2	-	3	-	-	-	2	2	3	2	2	3

Detailed syllabus:

Game Theory: Formulation of two-person zero-sum games, games with mixed strategies,graphical solution procedure, solving by linear programming.

Decision Analysis: Decision making with and without experimentation, decision trees, utilitytheory.

Queuing Theory and simulation: Basic structure of queuing models, birth-and-death process, basic queuing models, blocking models, priority-discipline models, queuing networks, essenceof simulation, generation of random numbers and observations, outline of simulation study.

Evolutionary optimization methods: Meta-heuristics, Tabu search, simulated annealing, genetic algorithms.

Reading:

1. Taha H.A., “Operations Research”, 10th Edition, Prentice Hall of India, New Delhi, 2016.
2. Hillier F.S. and Lieberman G.J., “Introduction to Operations Research”, 7th Edition, TMH,

2009.

3. Kalyanmoy Deb, “Multi-objective Optimization using Evolutionary Algorithms”, John Wiley & sons, 2001.

ME470	**SUPPLY CHAIN MANAGEMENT**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: Nil

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

CO1	Relate competitive and supply chain strategies.
CO2	Identify drivers of supply chain performance.
CO3	Analyze factors influencing network design.
CO4	Analyze the influence of forecasting in a supply chain.
CO5	Evaluate the role of aggregate planning, inventory, IT and coordination in a supply chain.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	-	-	-	-	2	2	-	-	2	2	2	2	2
CO2	3	-	-	-	-	2	2	2	-	2	2	2	2	2
CO3	3	3	3	3		2	2	2	2	2	2	2	2	3
CO4	3	3	3	3	3	3	2	2	3	2	2	2	3	3
CO5	3	2	3	-	3	3	2	2	3	2	2	2	3	3

Detailed syllabus:

Strategic Framework: Introduction to Supply Chain Management, Decision phases in a supply chain, Process views of a supply chain: push/pull and cycle views, Achieving Strategic fit, Expanding strategic scope.

Supply Chain Drivers and Metrics: Drivers of supply chain performance, Framework for structuring Drivers, Obstacles to achieving strategic fit.

Designing Supply Chain Network: Factors influencing Distribution Network Design, Design options for a Distribution network, E-Business and Distribution network, Framework for Network Design Decisions, Models for Facility Location and Capacity Allocation.

Forecasting in SC: Role of forecasting in a supply chain, Components of a forecast and forecasting methods, Risk management in forecasting.

Aggregate Planning and Inventories in SC: Aggregate planning problem in SC, Aggregate Planning Strategies, Planning Supply and Demand in a SC, Managing uncertainty in a SC: Safety Inventory.

Coordination in SC: Modes of Transportation and their performance characteristics, Supply Chain IT framework, Coordination in a SC and Bullwhip Effect

Reading:

1. Sunil Chopra and Peter Meindl, "Supply Chain Management - Strategy, Planning and Operation", 6thEdition, Pearson Education Asia, 2016.
2. David Simchi-Levi, PhilpKamintry and Edith Simchy Levy, "Designing and Managing the Supply Chain - Concepts Strategies and Case Studies", 3rd Edition, TMH, 2008.

Service Courses offered by DMEC to Other Departments

ME235	**Strength of Materials**	**PCC**	**4-0-0**	**4 Credit**

Pre-Requisites: CE 101: Engineering Mechanics

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

CO1	Understand the basic Mechanical properties of materials and testing procedure of materials
CO2	Understand statically determinate and indeterminate problems. Analyze thin cylinders and deflection of beam
CO3	Determine the resistance and deformation in machine members subjected to axial, flexural and torsional loads.
CO4	Evaluate principal stresses, strains and apply the concept of failure theories for design.

Detailed Syllabus:

Mechanical Fundamentals of materials and Testing: Basic assumptions of materials, Testing of materials-Non-Destructive Testing, Tensile testing, compression testing - Hardness Testing-Impact testing, Fatigue testing, Creep, other related testing methods characterization of TEM, XRD, SEM,

Resistance and Deformation: Concept of Resistance and deformation - Determinate and Indeterminate problems in Tension and Compression - Thermal Stresses - pure shear - young's modulus of elasticity, Poisson's ratio, Modulus of rigidity and Bulk modulus - Relation between elastic constants - Stress-strain diagrams for brittle and ductile materials - working stress - Strain energy in tension and compression - Impact loading.

Thin Cylinders: Thin Cylinders - spherical shells subjected to internal fluid pressure - Wire wound thin cylinders - Compound cylinders - Shrink fit.

Shear Force and Bending Moment: Types of supports - Types of beams - Types of loads - articulated beams - Shear Force and Bending Moment diagrams.

Theory of Simple Bending: Assumptions - Bending stresses in beams - Efficiency of various cross sections - Composite beams.

Shear Stress Distribution: Flexural shear stress distribution in different cross sections of beams.

Torsion of Circular cross sections: Theory of pure torsion - transmission of Power in Solid and Hollow circular shafts - Combined bending and torsion.

Principal Stresses and Strains: Analysis of Biaxial state of stress with and without shear - Mohr's Circle

Theories of failure: Dilation - Distortion - Maximum Principal Stress Theory - Maximum Principal Strain Theory - Maximum Shear Stress Theory - Strain Energy Theory - Distortion energy theory.

Reading:

1. Goodno, Barry J., and James Gere. Statics and Mechanics of Materials. Cengage Learning, 2018.
2. Shames, I. H., & Pitarresi, J. M. Introduction to Solid Mechanics, 2000.
3. Timoshenko and Gere, Mechanics of Materials, CBS Publishers, 2011.
4. E.P.Popov, Engineering Mechanics of Solids, PHI, 2009.
5. S. B. Junarkar, Mechanics of Structures, Charotar Publishers, 2010.
6. George E. Dieter, Mechanical Metallurgy, Mc Graw Hill,3rd Edition,2017
7. Suryanarayana AVK, Testing of Metallic Materials,BS Publications,2nd Edition, 2007.

OPEN ELECTIVES 1

(Offered to Other Department Students)

ME340	**AUTOMOTIVE MECHANICS**	**OPC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: Nil

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

CO1	Analyze operation and performance indicators of transmission systems, internal combustion engines and after treatment devices.
CO2	Understand operation of engine cooling system, lubrication system, electrical system, and ignition system.
CO3	Understand fuel supply systems in a diesel and petrol vehicles
CO4	Analyze current and projected future environmental legislation and its impact on design, operation, and performance of automotive power train systems.
CO5	Understand operation and performance of suspension, steering and braking system.
CO6	Understand layout of automotive electrical and electronics systems.

Course Articulation Matrix:

PO / **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	-	-	-	-	-	-	-	-	-	-	-	-
CO2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	3	2	-	-	-	3	3	-	-	-	-	-	-	-
CO5	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	2	-	-	-	-	-	-	-	-	-	-	-	-	-

Detailed syllabus:

Introduction: Layout of an automotive chassis, engine classification.

Cooling Systems: Air cooling, air cleaners, Water cooling: Thermosyphon and pump circulationsystems, Components of water-cooling systems- Radiator, thermostat etc.

Engine Lubrication: Petroils system, Splash system, Pressure lubrication and dry sump system

Ignition System: Battery, Magneto, and Electronic, Engine Starting drives

Fuel supply system: Components in fuel supply system, types of feed pumps, air cleaners, fueland oil filters, pressure, and dry sump systems.

Engine testing and Performance: Performance parameters, constant and variable speed test, heat balance test, performance characteristics. Engine Emissions: SI and CI engine emissions, emission control methods

Automotive electrical and electronics: Electrical layout of an automobile, ECU, sensors, windscreen wiper, Electric horn.

Transmission: Clutch**-** Single and multi-plate clutch, semi & centrifugal clutch and fluid flywheel, Gear box: Sliding mesh, constant mesh and synchromesh gear box, selector mechanism, over drive, Propeller shaft and Differential.

Suspension System: Front and rear suspension, shock absorbers, Rear Axles mountings,Front Axle. Steering Mechanism: Manual and power steering systems, Braking System: Mechanical, Hydraulic and Air braking systems.

Engine service: Engine service procedure.

Reading:

1. S. Srinivasan, Automotive Mechanics, Tata McGraw-Hill, 2004.
2. K.M.Gupta, Automobile Engineering, Vol.1 and Vol.2, Umesh Publications, 2002
3. Kirpal Singh, Automobile Engineering, Vol.1 and Vol.2, Standard Publishers, 2003.
4. William H.Crouse and Donald L. Anglin, Automotive Mechanics, Tata McGraw-Hill, 2004
5. Joseph Heitner, Automotive Mechanics, East-West Press, 2000.

ME341	**NEW VENTURE CREATION**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: Nil

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

CO1	Understand entrepreneurship and entrepreneurial process and its significance in economic development.
CO2	Develop an idea of the support structure and promotional agencies assisting ethical entrepreneurship.
CO3	Identify entrepreneurial opportunities, support, and resource requirements to launch a new venture within legal and formal framework.
CO4	Develop a framework for technical, economic, and financial feasibility.
CO5	Evaluate an opportunity and prepare a written business plan to communicate business ideas effectively.
CO6	Understand the stages of establishment, growth, barriers, and causes of sickness in industry to initiate appropriate strategies for operation, stabilization, and growth.

Course Articulation Matrix:

PO / **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	-	-	-	-	-	3	1	3	2	2	3	-	-	-
CO2	-	-	-	-	-	3	1	3	2	2	3	-	-	-
CO3	-	-	-	-	-	3	1	3	2	2	3	-	-	-
CO4	-	-	-	-	-	3	1	3	2	2	3	-	-	-
CO5	-	-	-	-	-	3	1	3	2	2	3	-	-	-
CO6	-	-	-	-	-	3	1	3	2	2	3	-	-	-

Detailed syllabus:

Entrepreneur and Entrepreneurship: Introduction; Entrepreneur and Entrepreneurship; Role of entrepreneurship in economic development; Entrepreneurial competencies and motivation; Institutional Interface for Small Scale Industry/Enterprises. **Establishing Small Scale Enterprise:** Opportunity Scanning and Identification; Creativity and product development process; Market survey and assessment; choice of technology and selection of site.

Planning a Small-Scale Enterprise: Financing new/small enterprises; Techno Economic Feasibility Assessment; Preparation of Business Plan; Forms of business organization/ownership.

Operational Issues in SSE: Financial management issues; Operational/project management issues in SSE; Marketing management issues in SSE; Relevant business and industrial Laws. **Performance appraisal and growth strategies:** Management performance assessment and control; Causes of Sickness in SSI, Strategies for Stabilization and Growth.

Reading:

1. Bruce R Barringer and R Duane Ireland, “Entrepreneurship: Successfully Launching New Ventures”, 3rd Edition, Pearson Education, 2013.
2. D.F. Kuratko and T.V. Rao, “Entrepreneurship: A South-Asian Perspective”, Cengage Learning, 2013.
3. Dr. S.S. Khanka, “Entrepreneurial Development”, 4th Edition, S Chand & Company Ltd., 2012.
4. Dr. Vasant Desai, “Management of Small-Scale Enterprises”, Himalaya Publishing House, 2004.

OPEN ELECTIVES 2

ME390	ALTERNATIVE SOURCES OF ENERGY	OPC	3 - 0 - 0	3 Credits

(Offered to Other Department Students)

Pre-requisites: Nil

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

CO1	Identify renewable energy sources and their utilization.
CO2	Understand basic concepts of solar radiation and analyze solar thermal systems for its utilization.
CO3	Understand working of solar cells and its modern manufacturing technologies.
CO4	Understand concepts of Fuel cells and their applications
CO5	Identify methods of energy storage.
CO6	Compare energy utilization from wind energy, geothermal energy, biomass, biogas and hydrogen.

Course Articulation Matrix:

PO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	-	1	-	3	3	-	-	-	-	2	-	-
CO2	3	3	3	2	-	1	3	-	-	-	-	2	-	-
CO3	3	3	3	3	2	1	3	-	-	-	-	2	-	-
CO4	3	3	3	1	2	1	3	-	-	-	-	2	-	-
CO5	2	3	2	1	1	1	3	-	-	-	-	2	-	-
CO6	2	3	2	1	1	1	3	-	-	-	-	2	-	-

Detailed Syllabus:

Introduction: Overview of the course; Examination and Evaluation patterns; Global warming;Introduction to Renewable Energy Technologies

Energy Storage: Introduction; Necessity of Energy Storage; Energy Storage Methods

Solar Energy: Fundamentals; Solar Radiation; Estimation of solar radiation on horizontal and inclined surfaces; Measurement of solar radiation data

Solar Thermal systems: Introduction; Basics of thermodynamics and heat transfer; Flat plate collector; Evacuated Tubular Collector; Solar air collector; Solar concentrator; Solar distillation; Solar cooker; Solar refrigeration and air conditioning; Thermal energy storage systems

Solar Photovoltaic systems: Introduction; Solar cell Fundamentals; Characteristics and classification; Solar cell: Module, panel, and Array construction; Photovoltaic thermal systems.

Wind Energy: Introduction; Origin and nature of winds; Wind turbine siting; Basics of fluid mechanics; Wind turbine aerodynamics; wind turbine types and their construction; Wind energy conversion systems

Fuel cells: Overview; Classification of fuel cells; operating principles; Fuel cell thermodynamics Biomass Energy: Introduction; Photosynthesis Process; Biofuels; Biomass Resources; Biomassconversion technologies; Urban waste to energy conversion; Biomass gasification.

Other forms of Energy: Introduction: Nuclear, ocean and geothermal energy applications;Origin and their types; Working principles

Reading:

1. Sukhatme S.P. and J.K.Nayak, Solar Energy - Principles of Thermal Collection and Storage, Tata McGraw Hill, New Delhi, 2008.
2. Khan B.H., Non-Conventional Energy Resources, Tata McGraw Hill, New Delhi, 2006.
3. J.A. Duffie and W.A. Beckman, Solar Energy - Thermal Processes, John Wiley, 2001.

ME391	**ROBUST DESIGN**	**OPC**	**3 - 0 - 0**	**3 Credits**

(Offered to Other Department Students)

Pre-requisites: Nil

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

CO1	Understand stages in engineering design and concept of robust design.
CO2	Develop quality loss functions and S/N ratios for S, N and L type objective functions.
CO3	Identify control and noise factors for a given product or process.
CO4	Conduct experiments using DOE concepts to decide the optimal setting of parameters
CO5	Apply quality loss function approach for fixing the component tolerances.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	-	2	-	-	-	-	-	-	-	-	2	-	-
CO2	3	-	-	3	-	2	2	-	-	-	-	2	-	-
CO3	3	3	-	2	-	-	-	-	-	-	-	2	-	-
CO4	3	3	3	3	3	-	-	-	-	-	-	2	-	-
CO5	3	2	-	-	-	2	2	-	-	-	-	2	-	-

Detailed syllabus:

Introduction: Taguchi’s quality philosophy, causes of performance variation, concept of robust design, stages in product/process design, need for experimentation, QFD, process flow analysis, cause, and effect diagram.

Design of Experiments: Principles of experimentation, Basic concepts of probability and statistics, Comparison of two means and two variances, Comparison of multiple (more than two) means & ANOVA, Factorial designs, fractional factorial designs, orthogonal

arrays, standard
orthogonal arrays & interaction tables, modifying the orthogonal arrays, selection of suitable orthogonal array design, analysis of experimental data.

Parameter Design: Loss function, average quality loss, S/N ratios, objective functions, selection of control & noise factors and their levels, strategy for systematic sampling of noise, classification of control factors, inner-array and outer-array design, data analysis, selection of optimum levels/values for parameters.

Tolerance Design: Experiments, selection of tolerances to be tightened, fixing the final tolerances.

Reading:

1. Taguchi G, Chowdhury S and Taguchi S, Robust Engineering, TMH, 2000.
2. Ross PJ, Taguchi Techniques for Quality Engineering, TMH, 2005.

OPEN ELECTIVES 3

ME490	**ENTREPRENEURSHIP**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: Nil.

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

CO1	Understand entrepreneurship and entrepreneurial process and its significance in economic development.
CO2	Develop an idea of the support structure and promotional agencies assisting ethical entrepreneurship.
CO3	Identify entrepreneurial opportunities, support and resource requirements to launch a new venture within legal and formal framework.
CO4	Develop a framework for technical, economic, and financial feasibility.
CO5	Evaluate an opportunity and prepare a written business plan to communicate business ideas effectively.
CO6	Understand the stages of establishment, growth, barriers, and causes of sickness in industry to initiate appropriate strategies for operation, stabilization, and growth.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	-	-	-	-	-	3	-	2	-	3	3	2	3	-
CO2	-	-	-	-	-	2	3	3	-	3	2	2	2	-
CO3	-	-	-	-	-	2	-	3	-	3	2	2	2	-
CO4	-	-	-	-	-	2	3	3	-	3	3	2	-	-
CO5	-	-	-	-	-	-	-	3	2	3	2	2	2	-
CO6	-	-	-	-	-	-	-	2	2	-	3	2	2	-

Detailed syllabus:

Entrepreneur and Entrepreneurship: Introduction; Entrepreneur and Entrepreneurship; Role of entrepreneurship in economic development; Entrepreneurial competencies and motivation; Institutional Interface for Small Scale Industry/Enterprises.
Establishing Small Scale Enterprise: Opportunity Scanning and Identification; Creativity and productdevelopment process; Market survey and assessment; choice of technology and selection of site.

Planning a Small-Scale Enterprise: Financing new/small enterprises; Techno Economic FeasibilityAssessment; Preparation of Business Plan; Forms of business organization/ownership.

Operational Issues in SSE: Financial management issues; Operational/project management issues inSSE; Marketing management issues in SSE; Relevant business and industrial Laws.

Performance appraisal and growth strategies: Management performance assessment and control; Causes of Sickness in SSI, Strategies for Stabilization and Growth.

Reading:

1. G.G. Meredith, R.E.Nelson and P.A. Neek, “The Practice of Entrepreneurship”, ILO, 1982.
2. Dr. Vasant Desai, “Management of Small-Scale Enterprises”, Himalaya Publishing House, 2004.
3. “A Handbook for New Entrepreneurs”, Entrepreneurship Development Institute of India, Ahmedabad, 1998.
4. Bruce R Barringer and R Duane Ireland, “Entrepreneurship: Successfully Launching New Ventures”, 3rd Edition, Pearson Education, 2013.

ME491	**PROJECT MANAGEMENT**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: Nil

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

CO1	Understand the importance of projects and its phases.
CO2	Analyze projects from marketing, operational and financial perspectives.
CO3	Evaluate projects based on discount and non-discount methods.
CO4	Develop network diagrams for planning and execution of a given project.
CO5	Apply crashing procedures for time and cost optimization.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	-	-	-	-	-	2	-	2	-	-	3	2	3	2
CO2	3	2	-	-	-	-	-	2	-	-	3	2	3	2
CO3	3	2	3	3	-	-	-	-	-	-	3	2	3	2
CO4	-	3	3	3	2	-	-	-	3	-	3	2	3	3
CO5	3	3	3	3	2	-	-	-	-	-	3	2	3	3

Detailed syllabus:

Introduction: Introduction to Project Management, History of Project Management, Project LifeCycle.

Project Analysis: Facets of Project Analysis, Strategy and Resource Allocation, Market andDemand Analysis, Technical Analysis, Economic and Ecological Analysis.

Financial Analysis: Financial Estimates and Projections, Investment Criteria, Financing ofProjects.

Network Methods in PM: Origin of Network Techniques, AON and AOA differentiation, CPMnetwork, PERT network, other network models.

Optimization in PM: Time and Cost trade-off in CPM, Crashing procedure, Scheduling when resources are limited.

Project Risk Management: Scope Management, Work Breakdown Structure, Earned Value Management, Project Risk Management.

Reading:

1. Prasanna Chandra, “Project: A Planning Analysis”, Tata McGraw Hill Book Company, New Delhi, 4th Edition, 2009.
2. Cleland, Gray and Laudon, “Project Management”, Tata McGraw Hill Book Company, New Delhi, 3rd Edition, 2007.
3. Jack R. Meredith and Samuel J., Jr. Mantel, “Project Management - A Managerial Approach”, John Wiley, 6th Edition, 2011.

ME449	PROJECT WORK PART - A	PRC	0 - 0 - 6	3 Credits

Pre-requisites: Nil

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

CO1	Identify a topic in advanced areas of Mechanical Engineering.
CO2	Review literature to identify gaps and define objectives & scope of the work.
CO3	Generate and implement innovative ideas for social benefit.
CO4	Develop a prototypes/models, experimental set-up, and software systems necessary to meet the objectives.

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	-	-	2	1	-	1	3	2	1	2	3	3
CO2	2	2	-	-	1	2	1	1	2	2	-	2	3	3
CO3	2	2	1	2	2	2	2	1	2	2	-	2	3	3
CO4	2	2	3	3	3	2	2	2	2	1	1	2	3	3

RUBRICS

Task	Performance indicators	Good 4	Satisfactory 3	Average 2	Poor 1
Selection of Topic	Selection of Topic	Selection of the topic by referring literature discussion with guide in two weeks.	Selection of the topic by referring research journals in a month	Selection of the topic by referring research journals in more than a month	Selection of the topic with the help of the guide

	Developing Project Plan & Distribution of work	Splitting the project into small tasks and scheduling them to finish it in time and division of the work among the members of the team is good and coordination in the team is good.	Splitting the project into small tasks and scheduling them to finish it in time and different tasks of the job shared among the members of the team with satisfactory coordination.	Splitting the project into small tasks is not sufficient and sharing different tasks among the team members need some more attention	Not able to split the project into small tasks. Needs lot of work to be done.
Literature Survey	Collection of Literature	Collected related research articles are Good and sufficient for the project work.	Collected related research articles are satisfactory for the project work.	Need some more research articles for the project work and need time.	Not collected relevant articles.
Performance of the task	Experiment Analysis/ Industrial Problem	Work completed in all aspects and is ready to prepare the dissertation.	Work completed 80%. Can start preparing, the dissertation.	Work completed only 50-60%. Need more attention to compete the tasks.	Work not completed. Need lot of attention.
	Teamwork	Coordinates team efforts and communication among members are good.	Coordinates team efforts and communication among members are satisfactory.	Requires more coordination and communication among the team	No proper coordination among the team
Review	Presentation	Presentation should be good with results and with good figures	Presentation is satisfactory with the results.	Presentation needs some improvement	Presentation in incomplete in all aspects.
		Understanding the task fully.	Ability of correlating the	Ability of correlating the	Ability of correlating the

	Understanding	Knowing all the tasks of the project. 100%.	theoretical aspects with the practical aspects are in between 60-80%	theoretical aspects with the practical aspects is in between 50-60%	theoretical aspects with the practical aspects is less than 50%

Dissertation Preparation	Dissertation Preparation	Dissertation prepared with neat sketches, and complete with all the necessary calculations or analysis, contents of the dissertation are well planned and coverage of all the topics is good	Dissertation prepared with neat sketches, and complete with all the necessary calculations or analysis, contents of the dissertation are well planned and coverage of all the topics is satisfactory	Dissertation prepared with sketches and required calculations but needs improvement	Dissertation prepared is not complete in all aspects and the coverage of all the contents is poor
Viva-voce	Understanding	Answering 100% questions related to the project	Answering 80% questions related to the project	Answering about 60% of questions related to the project	Answering, less than 50% of the questions related to the project
	Response	Responding immediately with confidence	Responding and answering to the satisfactory level	Responding with much delay and answering about 50% of the questions	Not able to respond. Understanding the concepts is poor

Mandatory Course - MOOCs

Student is required to complete two courses offered by the following agencies. The student is required to take prior approval from the Department, before registering for anycourse. The student must register for such courses in 5th Semester and 8th semester. Unless the student submits a pass certificate, he/she shall not be eligible for the award of degree.

ASME: American Society of Mechanical Engineer Certification Program - www.asme.org

SWAYAM: www.swayam.gov.in

NPTEL: www.onlinecourse.nptel.ac.in

Course Era: www.coursera.org

Free Online Courses: www.edx.org

MIT Open Course ware: www.ocw.mit.edu

ME499	**PROJECT WORK PART - B**	**PRC**	**0 - 0 - 12**	**6 Credits**

Pre-requisites: Nil.

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

CO1	Identify methods and materials to carry out experiments/develop code.
CO2	Reorganize the procedures with a concern for society, environment, and ethics.
CO3	Analyze and discuss the results to draw valid conclusions.
CO4	Prepare a report as per recommended format and defend the work.
CO5	Explore the possibility of publishing papers in peer reviewed journals/conference proceedings.

Course Articulation Matrix:

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	-	2	2	1	1	2	2	1	2	3	3
CO2	1	1	2	2	-	-	2	2	1	2	1	2	3	3
CO3	2	2	-	3	-	-	-	-	2	2	-	1	3	3
CO4	-	-	-	2	-	-	-	2	2	3	-	1	3	3
CO5	-	1	-	2	2	-	-	2	2	3	-	1	3	3

RUBRICS:

Task	Performance indicators	Good 4	Satisfactory 3	Average 2	Poor 1
Selection of Topic	Selection of Topic	Selection of the topic by referring literature discussion with guide in two weeks.	Selection of the topic by referring research journals in a month	Selection of the topic by referring research journals in more than a month	Selection of the topic with the help of the guide

	Developing Project Plan & Distribution of work	Splitting the project into small tasks and scheduling them to finish it in time and division of the work among the members of the team is good and coordination in the team is good.	Splitting the project into small tasks and scheduling them to finish it in time and different tasks of the job shared among the members of the team with satisfactory coordination.	Splitting the project into small tasks is not sufficient and sharing different tasks among the team members needs some more attention	Not able to split the project into small tasks. Needs lot of work to be done.
Literature Survey	Collection of Literature	Collected related research articles are Good and sufficient for the project work.	Collected related research articles are satisfactory for the project work.	Need some more research articles for the project work and need time.	Not collected relevant articles.
Performance of the task	Experiment Analysis/ Industrial Problem	Work completed in all aspects and is ready to prepare the dissertation.	Work completed 80%. Can start preparing, the dissertation.	Work completed only 50-60%. Need more attention to compete the tasks.	Work not completed. Need lot of attention.
	Teamwork	Coordinates team efforts and communication among members is good.	Coordinates team efforts and communication among members is satisfactory.	Requires more coordination and communication among the team	No proper coordination among the team
Review	Presentation	Presentation should be good with results and with good figures	Presentation is satisfactory with the results.	Presentation needs some improvement	Presentation in incomplete in all aspects.

	Understanding	Understanding the task fully. Knowing all the tasks of the project. 100%.	Ability of correlating the theoretical aspects with the practical aspects is in between 60-80%	Ability of correlating the theoretical aspects with the practical aspects is in between 50-60%	Ability of correlating the theoretical aspects with the practical aspects is less than 50%
Dissertation Preparation	Dissertation Preparation	Dissertation prepared with neat sketches, and complete with all the necessary calculations or analysis, contents of the dissertation are well planned and coverage of all the topics is good	Dissertation prepared with neat sketches, and complete with all the necessary calculations or analysis, contents of the dissertation are well planned and coverage of all the topics is satisfactory	Dissertation prepared with sketches and required calculations but needs improvement	Dissertation prepared is not complete in all aspects and the coverage of all the contents is poor
Viva-voce	Understanding	Answering 100% questions related to the project	Answering 80% questions related to the project	Answering about 60% of questions related to the project	Answering, less than 50% of the questions related to the project
	Response	Responding immediately with confidence	Responding and answering to the satisfactory level	Responding with much delay and answering about 50% of the questions	Not able to respond. Understanding the concepts is poor

Minor in Automation and Robotics

MEM251	MECHANISMS AND MACHINES	PCC	3 - 0- 0	3 Credits

Pre-requisites: CE101: Engineering Mechanics

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

CO1	Understand the principles of kinematic pairs, chains and their classification, DOF, inversions. Analyze the planar mechanisms for position, velocity and acceleration.
CO2	Evaluate gear tooth geometry and select appropriate gears for the required application.
CO3	Design cams and followers for specified motion profiles. Construct turning moment diagrams for various engines. Analyze and design centrifugal governors and flywheels
CO4	Understand the gyroscopic effects in ships, aero planes and road vehicles.
CO5	Analyze balancing problems in rotating and reciprocating machinery.

Course Articulation Matrix:

PO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	2	-	2	-	-	-	-	2	3	2
CO2	2	3	2	3	-	2	2	-	-	-	-	2	3	2
CO3	2	2	3	3	2	-	2	-	-	-	-	2	3	2
CO4	2	2	3	2	-	-	2	-	-	-	-	2	3	2
CO5	2	2	2	-	2	2	2	-	-	-	-	2	3	2

Detailed Syllabus:

Introduction: Mechanism and Machine, Kinematic Link, Kinematic Pair, Classification, Kinematic Chain, Linkage, Gruebler’s criterion for degrees of freedom, Grashof’s criterion, Kinematic inversions: Four bar mechanism, slider crank mechanism, Double slider-crank mechanism.

Kinematic Analysis: Position analysis, Instantaneous center, Kennedy’s theorem, locating instantaneous centers, Velocity analysis using Instantaneous Center method, Acceleration analysis, Coriolis Component of acceleration, four-bar mechanism, Slider crank mechanisms.

Gears : Types of gears, gear nomenclature, involute and cycloidal tooth profiles, Path of contact, Arc of contact, Contact ratio, Interference and Undercutting, Methods for eliminating Interference, Minimum number of teeth to avoid interference. Simple gear trains.

Cams & Followers: Fundamental law of Cam, Cam Terminology, Classification of Cams and followers, Analysis of follower motions (Displacement, velocity, Acceleration): Simple Harmonic, Uniform Velocity and Constant Acceleration, Generation of Cam Profiles by Graphical Method for knife-edge follower, flat-faced follower, eccentric followers.

Turning Moment Diagram and Flywheel: Turning moment diagram. Turning moment diagrams for different types of engines, Fluctuation of energy and fluctuation of speed. Dynamic Theory of Flywheel, Flywheel of an internal combustion engine.

Governors: Watt, Porter, Proell, Hartnel Governosr. Performance parameters: Sensitiveness, Stability, Hunting, Isochronism. Governor Effort and Power, Controlling Force & Controlling Force Curve, Friction & insensitiveness, Comparison between governor and flywheel.

Gyroscopes: Introduction to Gyroscopes. Gyroscopic forces and Couple. Effect of Gyroscopic Couple on Aeroplanes, Gyroscopic stabilization of ship, Stability of Two Wheelers and Four Wheelers. Rigid disc at an angle fixed to rotating shaft.

Balancing: Static and Dynamic Balancing,. Balancing of Several Rotating Masses rotating in same plane and in Different planes. Effect of Inertia Force due to Reciprocating Mass.

TEXT BOOKS

1. Amitabha Ghosh and Ashok Kumar Mallik, Theory of Mechanisms and Machines, East West Press Pvt. Ltd., New Delhi (2017)
2. Shigley J. E. and John Joseph Uicker, Theory of Machines and Mechanisms, Tata McGraw-Hill international edition, New York (2003)
3. Norton, R.L., Design of Machinery - An introduction to Synthesis and Analysis of Mechanisms and Machines, McGraw Hill International Edition, New York (2000).
4. S.S.Rattan, Theory of Machines, McGraw-Hill Publications, New Delhi (2011).

MEM301	AUTOMATION TECHNOLOGIES IN INDUSTRIES	3-0-0	3 Credits

Pre-requisites: Nil

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

CO1	Understand principles, strategies, advantage of industrial automation
CO2	Material handling and material storage systems for an automated factory
CO3	Industrial control systems and automation components
CO4	Outline the IoT technologies used in a manufacturing plant and their role in industry

Course Articulation Matrix:

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

Detailed syllabus:

Introduction: Automation overview, requirement of automation systems, principle, and strategies of automation systems, advanced automation functions, levels of automations, merit, and demerits of automation, Introduction of PLC and supervisory control and data acquisition (SCADA).

Industrial control systems: Process industries, Discrete manufacturing industries, levels of automation in the process and discrete manufacturing industries, variables and parameters in the process industries and discrete manufacturing industries, Different control systems: continuous and discrete control systems. Brief introduction to computer aided measurements and programmable logic controller.

Automation components: Sensors for temperature, pressure, force, displacement, speed, flow, level, humidity and pH measurement.

Material handling systems and design: Introduction to material handling and material transport systems, Intelligent Transportation Systems. Automation storage systems and retrieval systems (ASRS). Bar code technology, radio frequency identification technology. Material Handling Systems Robotics. Amazon MH system in fulfilment centres, Walmart stacking system, D-mart and the Indian FMCG strategy of large-scale stacking.

Industry 4.0: Introduction to Industry 4.0, China 2025 manufacturing system, The Various Industrial Revolutions, Challenges for Industry 4.0, Comparison of Industry 4.0 Factory and Today's Factory. Internet of Things (IoT) & Industrial Internet of Things (IIoT) & Internet of

Services, Smart Manufacturing, Smart Devices and Products, Smart Logistics, Smart Cities, Predictive Analytics. Examples of Ford assembly line and Model-T.

Technologies for enabling Industry 4.0: Technologies for enabling Industry 4.0 and Servitization : Servitization in Manufacturing, Cyber Physical Systems, Robotic Automation and Collaborative Robots, Support System for Industry 4.0, Digital Twins, Mobile Computing, Cyber Security, IIoT case studies, Industry 4.0 in healthcare services, Strategies for competing in an Industry 4.0 world.

Text Books:

1. Groover M. P., “Automation production Systems and Computer Integrated Manufacturing”, Pearson Education, 2013.
2. Krishna Kant, “Computer Based Industrial Control”, Prentice Hall of India, New Delhi, 2010.
3. Tiess Chiu Chang and Richard A. W., “An Introduction to Automated Process Planning Systems”, Tata McGraw-Hill Publishing Company, New Delhi, 2012
4. Alasdair Gilchrist, “Industry 4.0: The Industrial Internet of Things”, Springer 2016.
5. Klafter, R. D., Chmielewski, T. A. and Negin M., “Robot Engineering-An Integrated Approach”, Prentice Hall of India, New Delhi, 2012.

MEM351	**MECHATRONIC SYSTEMS**	**PCC**	**3-0-0**	**3 Credits**

Pre-requisites: EC101: Basic Electronic Engineering

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

CO1	Identify sensors, transducers and actuators to monitor and control the behaviour of process or a system.
CO2	Model and analyse mechatronic systems for an engineering application
CO3	Design of controller system for different applications
CO4	Evaluate the performance of mechatronic systems.

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	3	2	2	-	-	-	2	-	-	2	2	3
CO2	3	2	2	3	2	-	-	-	2	-	2	-	2	2
CO3	3	3	2	2	3	-	2	2	2	-	-	-	2	2
CO4	3	2	2	2	3	-	2	2	2	-	-	2	2	2

Detailed Syllabus:

Introduction: Introduction to mechatronic systems and components, need and integration of mechatronics at different levels of manufacturing, Principles of basic electric circuits and its components, Digital electronics review: number system, gates, flip-flops, counters, registers, tri-state concept, TTL and CMoS circuits, memories.

Actuators: Mechanical actuators, hydraulic and pneumatic actuator systems, Electrical Actuators: Solenoids, relays, diodes, thyristors, triacs, BJT, FET, DC motor, Servo motor, BLDC Motor, AC Motor, stepper motors. Hydraulic & Pneumatic devices - Power supplies, valves, cylinder sequencing, Piezoelectric actuators, Shape memory alloys.

Sensors: Sensor performance metrics**,**displacement, position, and proximity sensors, force sensors, fluid flow measurement sensors, vibration measurement (velocity and acceleration) sensors, tactile sensors, temperature sensors, selection of sensors.

Signal Conditioning: Amplifiers: Operational amplifiers, inverting amplifier, differential amplifier. Protection, comparator, Filters: low pass, high pass, band pass, band stop filters. Multiplexer, Pulse width Modulation Counters, decoders, Artificial intelligence based conditioning. Data acquisition - Quantizing theory, Analog to digital conversion, Digital to analog conversion.

Basic System Models & Analysis: Modelling of Mechanical, Electrical, Fluid and thermal systems, Block diagram representations for these systems. Dynamic Response, transfer function and frequency response of the systems.

Controllers: Classification of control systems, Feedback, closed loop and open loop systems, Continuous and discrete processes. Control modes, two step Proportional, Derivative, Integral, PID controllers. Digital controllers, programme logic controllers and PLC programming.

1. **Case studies of Mechatronics systems:** Pick and place robot, Bar code, Engine Management system, Washing machine etc.
2. **Industry 4.0 Concepts:** Introduction, IoT Techniques, Cloud computing, machine learning, Digital Twin.

Text Books:

1. W. Bolton, "Mechatronics", 5thEdition, Addison Wesley Longman Ltd, 2010
2. Devdas Shetty& Richard Kolk, "Mechatronics System Design", 3rdEdition. PWS Publishing, 2009.
3. Alciatore David G &Histand Michael B, "Introduction to Mechatronics and Measurement systems", 4thEdition, Tata McGraw Hill, 2006.

MEM401	**CNC AND ROBOTICS**	**PCC**	**3 - 0- 0**	**3 Credits**

Pre-requisites: MEM201: Mechanisms & Machines, ME254: Geometric modelling for CAD

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

CO1	Perform kinematic and dynamic analysis of robots
CO2	Develop commands for sensors and Program robots
CO3	Develop CNC program for different contours
CO4	Operate and maintain CNC machines

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	3	3	2	3	3	-	3	2	-	3	3	2
CO2	3	2	3	3	3	3	3	2	3	3	-	3	3	2
CO3	3	3	3	2	3	2	2	-	2	3	-	3	2	3
CO4	3	-	-	-	3	2	3	-	-	3	-	3	2	3

Introduction: History of CNC, Advantages and disadvantages of NC, CNC& DNC, block diagram of CNC, Principle of operation, Features available in CNC systems. History of robotics, Types of industrial robots, Applications of robots, Laws of robotics, robotic material handling, Robot centred cell, Factors influencing the choice of a robot, robot performance testing, economics of robotization, Impact of robot on industry and society. Robot Specification, Anatomy of a Robot, Robot classifications, representation of robot arms, common types of arms, Robot end effectors-Types, Tools as end effectors, Considerations in gripper selection and design.

Robot Kinematics & Dynamics: Frames and transformations, forward and inverse kinematics, DH representation, derivation of forward and Inverse kinematic equations for various types of robots,Introduction to manipulator Jacobian: singularity, Jacobian in force domain, velocity propagation fromlink to link, static forces in manipulators, introduction to dynamic analysis: Lagrangian formulation, trajectory planning: joint space and Cartesian space.

Robot Programming: Methods of robot programming- Textual and Leadthrough, WAIT, SIGNAL and DELAY commands, Capabilities and limitations of leadthrough programming, Robot language structure, Motion, sensor and end effectors commands, Programming examples.

CNC Control & Drive Units: System hardware, contouring control. Parameters and diagnosis features. Hardware and I/O configuration. Analog and digital drives. AC & DC servomotors, stepper motors and spindle motors. Selection criteria, drive optimization and protection.

Computer Aided Programming: Hardware & Software Interpolators, Designation of axis in CNC systems. EIA and ISO codes, Explanation of basic codes. APT programming, Manual part programming: Basic (Drilling, milling, turning etc.). Introduction to CAD/CAM software, Automatic Tool Path generation.

Tooling for CNC Machines: Interchangeable tooling system, preset and qualified tools, coolant fed tooling system, modular fixturing, quick change tooling system, automatic head changers. DNC Systems and Adaptive Control.

Economics and Maintenance: Factors influencing selection of CNC Machines, Cost of operation of CNC Machines, Practical aspects of introducing CNC machines in industries, Maintenance of CNC Machines Preventive Maintenance, TPM, Importance of earthing on the performance and life of machines.

Textbooks:

1. Rao, P.N. “CAD/CAM: Principles and Applications”, Tata McGraw-Hill Education, 2010
2. Saha S.K., "Introduction to Robotics", Tata McGraw-Hill Education, 2008.
3. Groover, M.P. “Industrial Robotics- Technology, Programming and Applications”, Tata McGraw-Hill Education, 2012
4. Sahin F., Kachroo P., “Practical and Experimental Robotics” CRC press, 2008.
5. Sinumerik CNC Controls Manuals.

Honors in Mechanical Engineering:

MEH301	COMPUTATIONAL METHODS IN MECHANICAL ENGINEERING	PCC	3-1-0	4 Credits

Course Outcomes:

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

CO1	Summarize the methods to obtain the governing equations for fluid flow.
CO2	Numerically solve for the steady state and transient heat transfer problem by FDM, FVM and FEM.
CO3	Numerically solve for the fluid flow problem at Peclet number by FVM.
CO4	Analyze the fluid flow problems using finite difference for incompressible viscous flow problems using SIMPLE algorithm.
CO5	Understand the basics of grid generation and grid transformation methods in two dimensions

Course Articulation Matrix:

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

SYLLABUS:

Introduction: History and Philosophy of computational fluid dynamics, CFD as a design and research tool, Applications of CFD in engineering,

Governing equations of fluid dynamics: Models of the flow, The substantial derivative, Physical meaning of the divergence of velocity, The continuity equation, The momentum equation, The energy equation, Navier-Stokes equations for viscous flow, Euler equations for inviscid flow, Physical boundary conditions, Forms of the governing equations suited for CFD, Conservation form of the equations.

Mathematical behavior of partial differential equations: Classification of quasi-linear partial differential equations, General behavior of Hyperbolic, Parabolic and Elliptic equations.

Numerical Grid Generation: Basic ideas, transformation and mapping, unstructured grid generation.

Finite Difference Method: Introduction, finite difference approximations, Taylor series expansion, polynomial fitting, approximation of boundary conditions, applications to conduction and advection-diffusion problems.

Finite Volume Method: Basic methodology, finite volume discretization, approximation of surface and volume integrals, interpolation methods – central and upwind formulations and comparison for convection-diffusion problem.

Solution of set of linear algebraic equations: Introduction to direct solvers, Gauss elimination and TDMA method. Introduction of iterative solvers, Jacobi, Gauss Seidel and SOR methods.

Time integration schemes: Explicit, implicit, mid-point and Crank –Nicolson method. Introduction to higher order methods.

Finite Element Method: Introduction to weighted residual method, sub domain, collocation, Galerkin, Petrov-Galerkin, and least square methods. Concept of finite element method, shape function generation in one and two dimensional elements. Applications of FEM to one dimension steady state heat conduction by Galerkin's method. Application of FEM to one dimension transient heat conduction along with demonstration of stability analysis.

Text Books/ References:

1. Hoffmann, K. A., & Chiang, S. T. Computational fluid dynamics volume I. Engineering Education System, 2000
2. Anderson, D.A., Tannehill, J.C. and Pletcher, R.H., "Computational Fluid Mechanics and Heat Transfer", 3rd Ed., Taylor & Francis , 2011
3. Anderson, J.D., Jr., "Computational Fluid Dynamics", McGraw Hill., 1995
4. Ferziger, J. H. and Peric, M., "Computational Methods for Fluid Dynamics", 3rd Ed., Springer., 2003
5. Versteeg, H. and Malalasekra, M., "An Introduction to Computational Fluid Dynamics: The Finite Volume Method", 2nd Ed., Pearson Education, 2007
6. Reddy, J. N. and Gartling, D. K., "The Finite Element Method in Heat Transfer and Fluid Dynamics", 3rd Ed., CRC Press., 2010
7. Chung, T. J., "Computational Fluid Dynamics". 2nd Ed., Cambridge University Press, 2010
8. Patankar, S. V., "Numerical Heat Transfer and Fluid Flow", Taylor and Francis, 1980.

MEH302	ARTIFICIAL INTELLEGENCE AND MACHINE LEARNING	PCC	3-1-0	4 Credits

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

CO1	Demonstrate basic concepts of artificial intelligence (AI) and its techniques.
CO2	Apply various AI techniques in solutions that require problem solving, inference, perception, knowledge representation, and learning.
CO3	Elucidate machine learning concepts, its classifications, supervised and unsupervised learning.
CO4	Dealt with functions and objectives of maintenance, strategies, scheduling and organization and various methods and policies of maintenance engineering
CO5	Describes the methods of fault diagnosis, types of sensors used for condition monitoring, frequency-time domain analysis and wavelets.

Course Articulation Matrix:

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

Syllabus:

UNIT-1
Introduction to Artificial Intelligence

Defining Artificial Intelligence, Defining AI techniques, Impact and Examples of AI

State Space Search and Heuristic Search Techniques-Defining problems as State Space search, Production systems and characteristics, Hill Climbing, Breadth first and depth first search, Best first search.

Knowledge Representation Issues- Representations and Mappings, Approaches to knowledge representation.

Using Predicate Logic and Representing Knowledge as Rules- Representing simple facts in logic, Computable functions and predicates, Procedural vs Declarative knowledge, Logic Programming, Forward vs backward reasoning.

Symbolic Logic under Uncertainty- Non-monotonic Reasoning, Logics for non-monotonic reasoning.

Statistical Reasoning- Probability and Bayes Theorem, Certainty factors, Probabilistic Graphical Models, Bayesian Networks, Markov Networks, Fuzzy Logic

Important Applications- Introduction to Natural Language Processing, Hopfield Networks, Neural Networks, Recurrent Networks.

UNIT 2

Introduction to Machine Learning

Idea of Machines learning from data, Classification of problem – Regression and Classification, Supervised and Unsupervised learning,

Linear regression- Model representation for single variable, single variable Cost Function, Gradient Decent for Linear Regression,

Logistic Regression- Classification, Hypothesis Representation, Decision Boundary, Cost function, Advanced Optimization, Multi-classification (One vs All), Problem of Overfitting, Regularization

Neural Networks-Non-linear Hypothesis, Biological Neurons, Model representation, Intuition for Neural Networks, Multiclass classification, Cost Function, Back Propagation Algorithm, Back Propagation Intuition, Weights initialization, Neural Network Training.

UNIT 3

Condition Monitoring and Maintenance Engineering

Basic Concepts: Machinery failures, basic maintenance strategies, preventive and predictive monitoring, factors influencing maintenance strategies, structural health monitoring, transducer selection and location, PC interfacing and virtual instrumentation. Vibration signatures of faults in rotating and reciprocating machines; detection and diagnosis of faults.

Unit 4

Instrumentation and Signal Processing

Types of sensors in condition monitoring: vibration, acoustics and noise, acoustic emission, temperature, ultrasonic and infra-red sensors - Signal processing: basic signal and systems concepts, time domain analysis, frequency domain analysis, time-frequency analysis, wavelets and wavelet packets.

Text Books & References:

1. Stuart J. Russel, Peter Norvig, Artificial Intelligence: A Modern Approach, Prentice Hall, Englewood Cliffs, New Jersey, 1995.
2. Elaine Rich and Kevin Knight, Artificial Intelligence, 2nd Edition, McGraw-Hill, 1991.
3. Tom M. Mitchell, Machine Learning, McGraw-Hill, 1997.
4. Richert W. & Coelho, Building Machine Learning Systems with Python,
5. Rao J. S., Vibration Condition Monitoring, Narosa Publishing House, 2/e 2000.
6. Isermann R., Fault Diagnosis Application, Springer-Verlag Berlin, 2011.

7. Allan Davis, Hand book of Condition Monitoring, Chapman and Hall, 2000.
8. Choudary K K., Instrumentation, Measurement and Analysis, Tata McGraw Hill, 2012
9. Collacott, R. A., Mechanical Faults Diagnosis, Chapman and Hall, London, 1990

MEH351	**Characterization of Materials**	**HC**	**3-0-2**	**4 Credits**

Pre-Requisite: PH101: Engineering Physics, MM235 Materials Engineering, CE237 Materials Testing Laboratory

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

CO1	Understand the X-Ray Diffraction, structures, phases, preferred crystal orientations (texture), and other structural parameters, such as average grain size, crystallinity, strain, and crystal defects
CO2	Understand the principle of operation of optical microscopy, SEM, EDX, TEM, RBS
CO3	Understand the principle of operation of thermal analysis, DTA, DSC and TGA
CO4	Understand the electrical and magnetic characterization techniques
CO5	Understand the optical and electronic characterization techniques

Course Articulation Matrix:

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	3	3	-	-	-	2	-	-	2	3	2
CO2	3	3	3	3	3	-	-	-	2	-	-	2	3	2
CO3	3	3	3	3	3	-	-	-	2	-	-	2	3	2
CO4	3	3	3	3	3	-	-	-	2	-	-	2	3	2
CO5	3	3	3	3	3	-	-	-	2	-	-	2	3	2

Detailed Syllabus:

Syllabus:

Introduction to materials and Techniques, Structure analysis tools: X-ray diffraction: phase identification, indexing and lattice parameter determination, Analytical line profile fitting using various models, Neutron diffraction, Reflection High Energy Electron Diffraction, and Low Energy Electron Diffraction; Microscopy techniques: Optical microscopy, transmission electron microscopy (TEM), energy dispersive X-ray microanalysis (EDS), scanning electron microscopy (SEM), Rutherford backscattering spectrometry (RBS), atomic force microscopy (AFM) and scanning probe microscopy (SPM); Thermal analysis technique: Differential thermal analysis (DTA), Differential Scanning Calorimetry (DSC), Thermo-gravimetric analysis (TGA); Electrical characterization techniques: Electrical resistivity, Hall effect, Magnetoresistance; Magnetic characterization techniques: Introduction to Magnetism, Measurement Methods, Measuring Magnetization by Force, Measuring Magnetization by Induction method, Types of measurements using magnetometers: M-H loop, temperature dependent magnetization, time dependent magnetization, Measurements using AC susceptibility, Magneto-optical Kerr effect, Nuclear Magnetic Resonance, Electron Spin Resonance; Optical and electronic characterization techniques: UV-VIS spectroscopy, Fourier transform infrared spectroscopy, Raman spectroscopy, X-ray photoelectron spectroscopy.

Lab with MME Dept.,

Text Books:

1. Characterization of Materials (Materials Science and Technology:A Comprehensive Treatment, Vol 2A & 2B, VCH (1992).
2. Semiconductor Material and Device Characterization, 3rd Edition, D. K. Schroder, Wiley-IEEE Press (2006).
3. Materials Characterization Techniques, S Zhang, L. Li and shok Kumar, CRC Press (2008).

References:

1. Physical methods for Materials Characterization, P. E. J. Flewitt and R K Wild, IOP Publishing (2003).
2. Characterization of Nanophase materials, Ed. Z L Wang, Willet-VCH (2000).

MEH352	**Servitization**	**HC**	**4 - 0 - 0**	**4 Credits**

Pre-requisites: ME203: Production Processes and Management, ME470: Supply Chain Management

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

CO1	One should be able to understand the need for a service-based economy
CO2	The difference between traditional thought and modern industry needs
CO3	Digitalization and its scope in industry with day-to-day examples
CO4	Data as the foundation for newer technologies and industrial processes
CO5	What the need is for zero defect and TQM in Supply chain
CO6	Practice of Servitization rather than the traditional product centric approach

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	-	3	2	-	-	3	-	3	2	2	3	2	2	-
CO2	-	3	2	-	-	3	-	3	2	2	3	2	2	-
CO3	-	3	2	-	-	3	-	3	2	2	3	2	2	-
CO4	3	3	2	3	-	3	-	3	2	2	3	2	2	-
CO5	3	3	2	3	-	3	-	3	2	2	3	2	2	-
CO6	-	3	2	-	-	3	-	3	2	2	3	2	2	-

Why Servitize: Supply chain, what is a service, what is a Product, intangibility, heterogeneity, inseparability, perishability. A primer on IoT, Case studies on Servitization: OLA, Uber, RO water plants in rural India.

21st Century thought: Change in thinking, abandoning the traditional manufacturing mindset, supply services, on-site maintenance of products, training to better utilize the products, production process consultancy to improve the effectiveness, asset management

Customer value: relative accessibility, efficiency, and effectiveness of the physical product, risk reduction + effectiveness of total company, Supplier and Customer perspective, Digital transformation

Classical theories: Competitive advantage by Michael Porter, Porters 5 forces, Value Migration by Adrian Slywotzky, Productivity improvements

Total Quality Management: Research and Development process, Strategic quality planning, Quality Councils – Employee involvement – Motivation, Empowerment, Team and Teamwork, Quality circles Recognition and Reward, Performance appraisal – Continuous process improvement – PDCA cycle, 5S, Kaizen – Supplier partnership – Partnering, Supplier selection, Supplier Rating

Servitization in Manufacturing: Product centric business model to service centric business, managing the transition from products to services, consolidation of product related services, entering the installed base service market, expanding to relationship-based services, expanding to process centred services, taking over the end users' operation, Robotic Automation and Collaborative Robots

Digitization vs Digitalization: Digitalization is a path not a goal, value creation for stakeholders, Value creator vs irritant approach, Simplification-Elimination-Expand-automate, Transformation from old economy to Digitalized

Data: 'Data is the new old'- reliance on data collection and big data in the new world, Data sharing, Remote services.

Reference Books:

1. Dale H. Besterfiled, et at., "Total quality Management", Pearson Education Asia, Third Edition, Indian Reprint 2006.
2. The Road to Servitization, How Product Service Systems Can Disrupt Companies' Business Models, Authors: Annarelli, Alessandro, Battistella, Cinzia, Nonino, Fabio
3. Practices and Tools for Servitization, Managing Service Transition, Editors (view affiliations), Marko KohtamäkiTim BainesRodrigo RabetinoAli Z. Bigdeli
4. Servitization Strategy and Managerial Control Anna Pistoni

MEH401	**Advanced Manufacturing Processes**	**HC**	**4-0-0**	**4 Credits**

Pre-requisites: ME203: Production Processes and Management, ME304: Machine Tools and Machining Science

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

CO1	understand material processing technique with the aim of cost reduction, reducing material wastage & machining time.
CO2	Understand and able to identify the process parameters affecting the product quality in various advanced machining of metals/ non-metals, ceramics and composites
CO3	Understand the joining processes as per the requirements of end products
CO4	Understand and categorize different material removal as per the requirements of material being used to manufacture end product.
CO5	Understand and able to combine & develop techniques from the state of art techniques available

Course Articulation Matrix:

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	3	3	-	2	2	-	-	-	-	2	3	2
CO2	3	3	3	3	-	2	2	-	-	-	-	2	3	2
CO3	3	3	3	3	-	2	2	-	-	-	-	2	3	2
CO4	3	3	3	3	-	2	2	-	-	-	-	2	3	2
CO5	3	3	3	3	-	2	2	-	-	-	-	2	3	2

Detailed Syllabus:

Advanced Casting Processes:

Stir casting, organic processes, Magnetic molding, high pressure molding, metal injection molding, centrifugal casting, Infiltration and Impregnation.

Advanced Welding Processes:

Electron beam welding, Laser beam welding, Friction Stir Welding: Principle, application and advantages of EBW, LBW and FSW process parameters.

Hybrid welding process and advantages and applications and surfacing,

Advanced Forming Processes:

Introduction forming processes: Design Considerations, Process parameters advantages, limitations and applications, Hydro, Magnetic and High velocity forming.

Advanced Machining Processes:

Classification of Advanced Machining Processes – Considerations in Process Selection, Applications.

Ultrasonic Machining, Electro – Chemical Machining, Thermal Metal Removal Processes, Electron Beam Machining, Laser Beam Machining, Plasma Machining, Abrasive Jet Machining, Water Jet Machining and Abrasive Water Jet Machining: Magnetic Abrasive Finishing, Abrasive Flow Finishing, Electro stream Drilling, Shaped Tube Electrolytic Machining.

Introduction to Recent developments in the Rapid Manufacturing and 3D Printing technologies

Text Books:

1. R. S. Mishra, Friction Stir Welding and Processing, ASM International, 2007.
2. Heine, Loper and Rosenthal, “Principles of Metal Casting”, Tata McGraw-Hill, New Delhi, 2008.
3. Jain, Vijay K., Advanced Machining Process, Chapter-7 (A) Electric Discharge Machining (EDM), Allied Publishers Pvt. Ltd., New Delhi, 2004, 126-129
4. Fundamentals of Machining Processes-Conventional and non – conventional processes/Hassan Abdel – Gawad El-Hafy/CRC Press-2016.
5. Modern Machining Process / Pandey P.C. and Shah H.S./ TMH.
6. New Technology / Bhattacharya A/ the Institution of Engineers, India 1984.