NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

B.Tech. in
MECHANICAL ENGINEERING

SCHEME OF INSTRUCTION AND SYLLABI

for B.Tech. Program

(Effective from 2021-22)

DEPARTMENT OF MECHANICAL ENGINEERING

Vision and Mission of the Institute

National Institute of Technology Warangal

VISION

Towards a Global Knowledge Hub, striving continuously in pursuit of excellence in Education, Research, Entrepreneurship and Technological services to the society

MISSION

- Imparting total quality education to develop innovative, entrepreneurial and ethical future professionals fit for globally competitive environment.
- Allowing stake holders to share our reservoir of experience in education and knowledge for mutual enrichment in the field of technical education.
- Fostering product-oriented research for establishing a self-sustaining and wealth creating centre to serve the societal needs.

Vision and Mission of the Department

Department of Mechanical Engineering

VISION

To be a global knowledge hub in mechanical engineering education, research, entrepreneurship and industry outreach services.

MISSION

- Impart quality education and training to nurture globally competitive mechanical engineers.
- Provide vital state of the art research facilities to create, interpret, apply and disseminate knowledge.
- Develop linkages with world class educational institutions and R&D organizations for excellence in teaching, research and consultancy services.

Department of Mechanical Engineering:

Brief about the Department:

The Department of Mechanical Engineering was established in the year 1959. The department presently offers one Under Graduate Programme, i.e., B.Tech in Mechanical Engineering with an intake of 170 students, seven M.Tech programs - Thermal Engineering, Manufacturing Engineering, Computer Integrated Manufacturing, Machine Design, Automobile Engineering, Materials and Systems Engineering Design, Additive Manufacturing – one P.G Diploma in Additive Manufacturing and and Ph.D programes. At present, the Department has 48 faculty members with research expertise in different specializations of Mechanical Engineering. The Department has good research facilities for both experimental as well as simulation-based research. The department has liaison with reputed industries and R&D organizations such as NFTDC, DMRL, DRDL, ARCI, BHEL, CMTI, CPRI etc. All the faculty of the department are actively engaged in R&D and Consultancy. Presently the department is handling about 25 funded projects worth Rs. 3.00 Crores. The department has recently acquired metal 3D printer at a cost of Rs.1.4 Crores under TEQIP -III grants. The institute is establishing SIEMENS Centre of Excellence in digital manufacturing and Industry 4.o in manufacturing in which the department is playing key role. The department produces a large number of publications, and offers solutions to the industry regularly and is also active with regular outreach activities like workshops, conferences and executive programs for industry personnel. The department has been recognized as QIP Centre for M.Tech and Ph. D. programmes.

List of Programs offered by the Department:

Program	Title of the Program
B.Tech.	Mechanical Engineering
M.Tech.	Thermal Engineering
	Manufacturing Engineering
	Computer Integrated Manufacturing
	Machine Design
	Automobile Engineering
	Materials and Systems Engineering Design
	Additive Manufacturing
PG Diploma	Additive Manufacturing
Ph.D.	Mechanical Engineering

Note: Refer to the following weblink for Rules and Regulations of B.Tech. program:
https://www.nitw.ac.in/media/uploads/2021/08/27/btech_rules-and-regulations-2021-22.pdf

B.Tech. – Mechanical Engineering

Program Educational Objectives

PEO-1	Plan, design, construct, maintain and improve mechanical engineering systems that are technically sound, economically feasible and socially acceptable to enhance quality of life.
PEO-2	Apply analytical, computational and simulation tools & techniques to address the challenges faced in mechanical and allied engineering streams.
PEO-3	Communicate effectively using innovative tools and demonstrate leadership & entrepreneurial skills.
PEO-4	Exhibit professionalism, ethical attitude, team spirit and pursue lifelong learning to achieve career and organizational goals.

Program Articulation Matrix

PEO / Mission Statements	**PEO1**	**PEO2**	**PEO3**	**PEO4**
Impart quality education and training to nurture globally competitive mechanical engineers	3	3	2	2
Provide vital state of the art research facilities to create, interpret, apply and disseminate knowledge	3	2	2	2
Develop linkages with world class educational institutions and R&D organizations for excellence in teaching, research and consultancy services	2	2	3	2

1-Slightly; 2-Moderately; 3-Substantially

B.Tech. – Mechanical Engineering

Program Outcomes

PO-1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and mechanical engineering to the solution of complex engineering problems.
PO-2	**Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO-3	**Design/Development of solutions**: Design solutions for complex mechanical engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO-4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO-5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex mechanical engineering activities with an understanding of the limitations.
PO-6	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.
PO-7	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO-8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO-9	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO-10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO-11	**Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO-12	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes

PSO-1	Apply mechanical engineering and interdisciplinary knowledge for analyzing, designing and manufacturing products to address the needs of the society.
PSO-2	Apply state of the art tools and techniques to conceptualize, design and introduce new products, processes, systems and services.

SCHEME OF INSTRUCTION

B.Tech. Mechanical Engineering – Course Structure

I - Year, I – Semester

S. No.	Course Code	Title of the Course	L	T	P	Credits	Cat. Code
1	CS131	Problem Solving and Computer Programming	3	0	2	4	ESC
2	MA133	Matrix Theory and Differential Calculus	3	0	0	3	BSC
3	CY135	Chemistry for Mechanical Engineering	2	0	0	2	BSC
4	ME101	Introduction to Mechanical Engineering	3	0	0	3	PCC
5	ME102	Design Thinking	0	1	4	3	PCC
6	ME103	Engineering Graphics	0	0	6	3	ESC
7	ME104	Workshop Practice	0	0	3	1.5	PCC
8	CY136	Chemistry laboratory for Mechanical Engineering	0	0	2	1	BSC
9	IC001	MNC-1 (Induction Program) *				0	MNC
10	IC101	MNC-2 (EAA) *	0	0	2	0	MNC
		Total	**11**	**1**	**19**	**20.5**	

* MNC weblink: https://www.nitw.ac.in/media/uploads/2021/10/22/mnc_1st-year.pdf

I - Year, II – Semester

S. No.	Course Code	Title of the Course	L	T	P	Credits	Cat. Code
1	MA183	Integral Calculus and Numerical Methods	3	0	0	3	BSC
2	PH181	Physics for Mechanical Engineering	2	0	0	2	BSC
3	HS181	Communication Skills and Report Writing	2	0	2	3	HSC
4	CE101	Engineering Mechanics	3	0	0	3	ESC
5	ME151	Design Studio	0	0	3	1.5	PCC
6	ME152	Kinematics of Machinery	3	0	0	3	PCC
7	ME153	Engineering Computation Laboratory	0	0	2	1	PCC
8	PH182	Physics laboratory for Mechanical Engineering	0	0	2	1	BSC
9	IC151	MNC-3 (EAA) *	0	0	2	0	MNC
		Total	**13**	**0**	**11**	**17.5**	

* MNC weblink: https://www.nitw.ac.in/media/uploads/2021/10/22/mnc_1st-year.pdf

Note: BSC – Basic Science Courses
ESC – Engineering Science Courses
PCC – Professional Core Courses
PEC – Professional Elective Courses
OEC – Open Elective Courses
HSC – Humanities and Social Science Courses
MNC– Mandatory Non-credit Courses
PRC – Project Course

II- Year, I – Semester

S. No.	Course Code	Title of the Course	L	T	P	Credits	Cat. Code
1	MA233	Transformation Techniques and Statistics	3	0	0	3	BSC
2	MM235	Materials Engineering	3	0	0	3	ESC
3	CE231	Mechanics of Solids	3	0	0	3	ESC
4	CE232	Fluid Mechanics and Hydraulic Machines	3	0	0	3	ESC
5	EE235	Basic Electrical and Electronics Engineering	2	0	0	2	ESC
6	ME201	Thermodynamics	3	0	0	3	PCC
7	ME202	Dynamics of Machinery	3	0	0	3	PCC
8	CE233	Material Testing Laboratory	0	0	2	1	ESC
9	CE234	Fluid Mechanics and Hydraulic Machines Laboratory	0	0	2	1	ESC
10	ME203	Kinematics and Dynamics Laboratory	0	0	2	1	PCC
		Total	**20**	**0**	**6**	**23.0**	

II- Year, II – Semester

S. No.	Course Code	Title of the Course	L	T	P	Credits	Cat. Code
1	SM283	Engineering Economics and Costing	3	0	0	3	HSC
2	EE281	Electrical Machines and Controls	3	0	2	4	ESC
3	ME251	Manufacturing Science	3	0	0	3	PCC
4	ME252	Design of Machine Elements	3	0	0	3	PCC
5	ME253	Heat Transfer	3	0	0	3	PCC
6	ME254	Prime Movers for Automobiles	3	0	0	3	PCC
7	ME255	Heat Transfer and Fuels Laboratory	0	0	2	1	PCC
8	ME256	Manufacturing Science Laboratory	0	0	3	1.5	PCC
9	ME257	Computer Aided Machine Drawing	0	0	3	1.5	PCC
10	IC251	MNC-4 *	0	0	2	0	MNC
		Total	**18**	**0**	**12**	**23.0**	

* MNC weblink: https://www.nitw.ac.in/media/uploads/2021/10/22/mnc_2nd-year.pdf

III- Year, I – Semester

S. No.	Course Code	Title of the Course	L	T	P	Credits	Cat. Code
1	ME301	Geometric Modelling for CAD	3	0	0	3	PCC
2	ME302	Machine Tools and Metrology	3	0	0	3	PCC
3	ME303	Mechanical Measurements	3	0	2	4	PCC
4	ME304	Design of Transmission Elements	3	0	0	3	PCC
5	ME305	Management Science and Productivity	3	0	0	3	PCC
6	ME306	Thermal Machines	3	0	0	3	PCC
7	ME3XX	Department Elective – I	3	0	0	3	PEC
8	ME307	Thermal Engineering Laboratory	0	0	3	1.5	PCC
		Total	**21**	**0**	**5**	**23.5**	

III- Year, II– Semester

S. No.	Course Code	Title of the Course	L	T	P	Credits	Cat. Code
1	ME351	Refrigeration and Air-Conditioning	3	0	0	3	PCC
2	ME352	Machining Science	3	0	0	3	PCC
3	ME353	Mechatronics	3	0	0	3	PCC
4	ME354	Operations Planning and Control	3	0	0	3	PCC
5	ME3XX	Department Elective – II	3	0	0	3	PEC
6		Open Elective – I #	3	0	0	3	OEC
7	ME355	Mechatronics Laboratory	0	0	2	1	PCC
8	ME356	CFD Laboratory	0	1	2	2	PCC
9	ME357	Machining and Metrology Laboratory	0	0	3	1.5	PCC
10	IC351	MNC-5 *	0	0	2	0	MNC
		Total	**18**	**1**	**9**	**22.5**	

* MNC weblink: https://www.nitw.ac.in/media/uploads/2021/10/22/mnc_3rd-year.pdf

OEC weblink: https://www.nitw.ac.in/media/uploads/2021/10/22/open-elective-1_vi-sem.pdf

IV- Year, I – Semester

S. No.	Course Code	Title of the Course	L	T	P	Credits	Cat. Code
1	ME401	Robotics	3	0	0	3	PCC
2	ME402	Computer Aided Manufacturing (CAM)	3	0	0	3	PCC
3	ME4XX	Department Elective – III	3	0	0	3	PEC
4	ME4XX	Department Elective - IV	3	0	0	3	PEC
5		Open Elective – II #	3	0	0	3	OEC
6	ME403	CAM Laboratory	0	0	2	1	PCC
7	ME404	Computer Aided Engineering (CAE) Laboratory	0	0	2	1	PCC
8	ME449	Summer Internship/EPICS	-			2	PCC
		Total	**15**	**0**	**4**	**19.0**	

OEC weblink: https://www.nitw.ac.in/media/uploads/2021/10/22/open-elective-2_vii-sem.pdf

IV- Year, II – Semester

S. No.	Course Code	Title of the Course	L	T	P	Credits	Cat. Code
1	ME4XX	Department Elective- V	3	0	0	3	PEC
2	ME4XX	Department Elective -VI	3	0	0	3	PEC
3	ME498	Seminar	0	0	2	1	SEM
4	ME499	Project Work @	0	0	8	4	PRC
		Total	**6**	**0**	**10**	**11.0**	

@ **NOTE: Refer to the following link for the guidelines to prepare dissertation report:**
https://www.nitw.ac.in/media/uploads/2021/08/27/ug_project-report-format_55vW5pL.pdf

Credits Distribution

Category	I Year, Sem – I	I Year, Sem – II	II Year, Sem – I	II Year, Sem – II	III Year, Sem – I	III Year, Sem – II	IV Year, Sem – I	IV Year, Sem – II	Total credits
BSC	6	6	3						15
HSC		3		3					6
ESC	7	3	13	4					27
PCC	7.5	5.5	7	16	20.5	16.5	8		81
PEC					3	3	6	6	18
OEC						3	3		6
MNC									0
Summer Internship							2		2
Seminar								1	1
Project								4	4
TOTAL	20.5	17.5	23	23	23.5	22.5	19	11	160

List of Electives

III Year, I Semester

Department Elective I

1 ME311 Mechanical Vibrations
2 ME312 Optimization for Engineering Design
3 ME313 Computational Fluid Dynamics
4 ME314 Alternate Fuels
5 ME315 Advanced Welding Technology
6 ME316 Advanced Metal Casting

III Year, II Semester

Department Elective II

1 ME361 Finite Element Method
2 ME362 Theory of Elasticity
3 ME363 Aerodynamics
4 ME364 Automobile Engineering
5 ME365 Advanced Metal Forming
6 ME366 Operations Research
7 ME367 Design and Analysis of Experiments

IV year, I-Semester

Department Elective- III

1. ME411 Non-Conventional Energy Sources
2. ME412 Automotive Safety
3. ME413 Cryogenics
4. ME414 Tool Design
5. ME415 Total Quality Management
6. ME416 Theory of Plasticity
7. ME417 Theory of Constraints
8. ME418 Condition Monitoring
9. ME419 Tribology

Department Elective-IV

1. ME421 Applied Heat Transfer
2. ME422 Gas Dynamics
3. ME423 Artificial Intelligence for Cyber Physical Systems
4. ME424 Micro and Nano Manufacturing
5. ME425 Supply Chain Management
6. ME426 Material Characterization
7. ME427 Fracture Mechanics

IV year, II-Semester

Department Elective-V

1. ME461 Power Plant Engineering
2. ME462 Two-Phase Heat Transfer
3. ME463 Machine Tool Design
4. ME464 Additive Manufacturing Processes & Applications
5. ME465 Project Management
6. ME466 Lubrication & Rotor Dynamics

Department Elective-VI

1. ME471 Fuel Cell Technology
2. ME472 Jet Propulsion and Rocketry
3. ME473 Reliability Engineering
4. ME474 Design for Manufacturing and Assembly
5. ME475 Advanced Materials Processing
6. ME476 Engineering Acoustics
7. ME477 Mechanics of Composite Materials

I Year, I Semester

Course Code: CS131	PROBLEM SOLVING AND COMPUTER PROGRAMMING	Credits 3-0-2: 4

Pre-Requisites: NIL

Course Outcomes:

CO1	Design algorithms for solving simple mathematical problems including computing, searching and sorting
CO2	Compare and contrast space and time complexity of algorithms for solving simple mathematical problems
CO3	Explore the internals of computing systems for developing efficient algorithms
CO4	Choose appropriate data types and structures for solving specific problems
CO5	Apply control structures for developing modular programs for solving mathematical problems
CO6	Apply object-oriented features for solving real world problems

Course Articulation Matrix:

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

Syllabus:

Fundamentals of Computers, Historical perspective, Early computers, Components of a computers, Problems, Flowcharts, Memory, Variables, Values, Instructions, Programs.

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

Number systems and data representation, Basics of C++, Basic data types.

Numbers, Digit separation, Reverse order, Writing in words, Development of Elementary School Arithmetic Testing System, Problems on Date and factorials, Solutions using flow of control constructs, Conditional statements - If-else, Switch-case constructs, Loops - while, do-while, for.

Functions – Modular approach for solving real time problems, user defined functions, library functions, parameter passing - call by value, call by reference, return values, Recursion, Introduction to pointers.

Sorting and searching algorithms, Large integer arithmetic, Single and Multi-Dimensional Arrays, passing arrays as parameters to functions.

Magic square and matrix operations using Pointers and Dynamic Arrays, Multidimensional Dynamic Arrays
String processing, File operations.

Structures and Classes - Declaration, member variables, member functions, access modifiers, function overloading, Problems on Complex numbers, Date, Time, Large Numbers.

List of Programs:
1. Programs on conditional control constructs.
2. Programs on loops (while, do-while, for).
3. Programs using user defined functions and library functions.
4. Programs on arrays, matrices (single and multi-dimensional arrays).
5. Programs using pointers (int pointers, char pointers).
6. Programs on structures.
7. Programs on classes and objects.

Learning Resources:

Text Books:

1. Problem Solving with C++, Walter Savitch, Pearson, 2014, 9th edition.
2. Big C++, Cay Horstmann, Timothy Budd, Wiley, 2009, 2nd edition.
3. How to solve it by Computer, R.G. Dromey, Pearson, 2008.

Course Code: MA133	MATRIX THEORY AND DIFFERENTIAL CALCULUS	Credits 3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Apply orthogonal and congruent transformations to a quadratic form
CO2	Find the maxima and minima of multivariable functions
CO3	Solve arbitrary order linear differential equations with constant coefficients
CO4	Apply Laplace transforms for solving differential equations arising in engineering

Course Articulation Matrix:

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

Syllabus:

Matrix Theory: Linear dependence and independence of vectors; 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 and congruent transformation

Differential Calculus: Taylor's theorem with remainders; Taylor's and Maclaurin's expansions; Functions of several variables - partial differentiation; total differentiation; Euler's theorem and generalization; maxima and minima of functions of several variables (2 and 3 variables)

Ordinary Differential Equations: Geometric interpretation of solutions of first order ODE; Exact differential equations; integrating factors; orthogonal trajectories; Higher order linear differential equations with constant coefficients - homogeneous and non-homogeneous; Euler and Cauchy's differential equations; Method of variation of parameters

Laplace Transforms: Laplace transforms; inverse Laplace transforms; Properties of Laplace transforms; Laplace transforms of unit step function, impulse function, periodic function; Convolution theorem; Applications of Laplace transforms

Learning Resources:

Text Books:

1. Advanced Engineering Mathematics, R. K. Jain and S. R. K. Iyengar, Narosa Publishing House, 2016, 5th edition.
2. Advanced Engineering Mathematics, Erwin Kreyszig, John Wiley and Sons, 2015, 8th edition.
3. Calculus and Analytic Geometry, George B. Thomas and Ross L. Finney, Pearson, 2020, 9th edition.

Reference Books:

1. Advanced Engineering Mathematics, Dennis G. Zill, Jones & Bartlett Learning, 2018, 6th edition.
2. Higher Engineering Mathematics, B. S. Grewal, Khanna Publishers, 2012, 42nd edition.

Course Code: CY135	CHEMISTRY FOR MECHANICAL ENGINEERING	Credits 2-0-0: 2

Pre-Requisites: NIL

Course Outcomes:

CO1	Apply the concepts of physical chemistry in developing batteries
CO2	Understand the chemistry involved in the synthesis and characterization of nanomaterials and apply the knowledge in developing various engineering materials
CO3	Understand the concepts of spectroscopy and apply the knowledge in characterizing the material using spectroscopic methods
CO4	Apply the knowledge to protect different metals from corrosion
CO5	Apply the concepts to reduce the environmental pollution

Course Articulation Matrix:

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

Syllabus:

Electrochemistry: Basic concepts of electrochemistry; Electrochemical cells: Galvanic cell (Daniel cell); Electrode potential; Electrochemical series and its applications; Nernst equation; Types of electrodes: Calomel electrode, quinhydrone electrode.

Corrosion and its control: Corrosion: Introduction, causes and effects of corrosion; Theories of corrosion: Chemical and electrochemical corrosion with mechanism; Factors affecting the rate of corrosion: Nature of the metal and nature of the environment; Types of corrosion: Waterline and crevice corrosion; Corrosion control methods: Cathodic protection- sacrificial anodic protection and impressed current cathodic protection; Surface coatings: Metallic coatings, methods of application of metallic coatings-hot dipping(galvanizing, tinning), electroplating(copper plating); Organic coatings: Paints, its constituents and their functions.

Water Technology: Water: Types of Hardness, Determination of temporary and permanent hardness of water by EDTA method; Boiler troubles: Priming, foaming, scales, sludges and caustic embrittlement. Treatment of water: Internal treatment of boiler feed water- carbonate, calgon and phosphate conditioning, softening of water by Zeolite process and Ion exchange process; Potable water-its specifications, steps involved in the treatment of potable water.

Material Chemistry: Polymers-classification with examples, polymerization-addition, condensation and co-polymerization; Plastics: Thermoplastics and thermosetting plastics; Compounding of plastics; Preparation, properties and applications of Polyvinylchloride, Teflon, Bakelite and Nylon-6; Rubbers: Natural rubber its process and vulcanization; Elastomers: Buna-s and Thiokol rubber; Fibers: Characteristics of fibers, Preparation properties and applications of Dacron; Characteristics of fiber reinforced plastics; Characterization of

Materials using Spectroscopic Methods (UV-Vis spectroscopy, Infrared spectroscopy, NMR spectroscopy).

Fuels and Combustion: Fuel: Definition, classification of fuels and characteristics of a good fuels; Solid fuels: Coal, analysis of coal- proximate and ultimate analysis; Liquid fuels: Petroleum and its refining; Cracking: Fixed bed catalytic cracking.

Learning Resources:

Text Books:

1. A Text Book of Engineering Chemistry, Shashi Chawla, Dhanpat Rai & Co., 2007, 6th edition.
2. Text Book of Engineering Chemistry, Ashutosh Kar, ED-Tech Publications, 2018.

Reference Books:

1. Inorganic Chemistry, Huheey, Pearson Publications India, 2006 , 4th edition.
2. Molecular Quantum Mechanics, Peter Atkins, Oxford University Press, 2012, 5th edition.
3. Advanced Organic Chemistry: Reaction Mechanism and Structure, Jerry March, John Wiley Publications, 2003, 4th edition.

Course Code: ME101	INTRODUCTION TO MECHANICAL ENGINEERING	Credits 3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Identify Materials for Engineering Applications
CO2	Comprehend the functioning of mechanisms and power transmission systems for a given application
CO3	Understand the fundamental concepts of thermodynamics, fluid mechanics, heat transfer and their applications to thermal machines
CO4	Understand manufacturing processes and the principles of operation of machine tools
CO5	Understand the principles of work study, CPM, PERT and Operations Research
CO6	Demonstrate clarity on evolution of mechanical engineering and self-learning of futuristic technologies

Course Articulation Matrix:

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

Syllabus:

Engineering Materials: Evolution during industrial revolutions**,** Introduction to Engineering Materials, Classification and Properties.

Design Engineering: Evolution during industrial revolutions, Simple to complex mechanisms -kinematics, dynamics, evolution of Automobile Engineering, Power Transmission, Fasteners and Bearings, introduction to - design of machine elements, CAD.

Thermal Engineering: Evolution during industrial revolutions, Fundamentals of Thermodynamics, fluid mechanics and heat transfer, Energy sources, Energy generation and conversion, Prime movers - Steam power, IC Engines, Introduction to - High altitude propulsion, Refrigeration and Air-Conditioning.

Production Engineering: Evolution during industrial revolutions, Manufacturing Processes – subtractive, confirmative and additive, Machine Tools – classification, working principle, surface finishing processes, introduction to CAM.

Industrial Engineering: Evolution during industrial revolutions, Scientific management, introduction to – work study, CPM, PERT and Operations Research.

Future of Mechanical Engineering: Industry 4.0-principles and concepts, Introduction to – Robotics, Autonomous vehicles - Artificial Intelligence and Machine Learning.

Learning Resources:

Text Books:

1. History of Mechanical Engineering, Ce Zhang, Jianming Yang, Springer, 2020, 1st edition.
2. A Brief History of Mechanical Engineering, Dixit, U., Hazarika, M. and Davim, J., Springer International Publishing, 2017, 1st edition.

Reference Books:

1. Basic Mechanical Engineering, Praveen Kumar, Pearson Education, 2018, 2nd edition.
2. Exploring Engineering: An introduction to Engineering and Design, Philip Kosky, Rober Balmer, William Keat, George Wise, Academic Press, 2015, 4th edition.
3. Saeed Movaveni, Engineering Fundamentals: An Introduction to Engineering, Cengage Learning India Pvt. Ltd., 2011, 4th edition.

Online Material:

1. https://www.bbc.co.uk/programmes/p00kjq6d
2. https://www.natgeotv.com/in/super-factories/videos
3. https://www.discoveryuk.com/series/how-do-they-do-it/
4. https://www.historyindia.com/show/how-trains-changed-the-world

Course Code: ME102	DESIGN THINKING	Credits 0-1-4: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Identify user needs
CO2	Define problems to stimulate ideation
CO3	Ideate on problems to propose solutions by working collaboratively
CO4	Test aspects of proposed solutions
CO5	Improve solutions by gaining user feedback

Course Articulation Matrix:

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

Syllabus:

Introduction to Engineering: "Engineering" as a vehicle for social and economic development; impact of science/engineering our day to day lives; process of engineering a product; various career options.

Introduction and identifying the need: Understanding the unique needs of the user - empathize - define - ideate - prototype - test. Case Studies - Develop appreciation for the design process and its application in specific settings (Guest lectures, Videos, Field visits, Interplay lectures of design-based movies).

Problem Formulation: Framing a problem statement neutrally using adequate checks. Case studies.

Concept Generation: Generate multiple concepts using various creativity tools and thinking styles.

Prototyping: select from ideas and make quick prototypes (mock-ups) using available material.

Evaluation: Iterative process of ideation, prototyping and testing-Take the mock-ups to users for feedback and iterate process till users feel delighted.

Activities:

Some of the activities which are undertaken as a part of this course include:

- Field Visits
- Case Studies on innovation, failures etc.
- Guest lecture
- Group Discussions

- Presentation by student
- Experiential learning workshops

Learning Resources:

Reference Books:

1. Design Thinking: A guide to creative problem solving for everyone, Andrew Pressman, Routledge Taylor and Francis group, 2019, 1st edition.
2. Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation, Tim Brown, Harper Business, 2019.
3. Engineering Design, George E. Dieter, Linda C. Schmidt, McGraw-Hill Education, 2019, 5th edition.
4. Product design and development, Ulrich, K., Eppinger, S. and Yang, M., 2020, 7th edition.

Online Resources:

1. https://www.arvindguptatoys.com/
2. https://honeybee.org/
3. https://dschool.stanford.edu/resources/getting-started-with-design-thinking
4. https://designthinking.ideo.com/

Course Code: ME103	ENGINEERING GRAPHICS	Credits 0-0-6: 3

Pre-Requisites: NIL

Course Outcomes:

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

CO1	Apply BIS standards and conventions while drawing Lines, printing Letters and showing Dimensions.
CO2	Classify the systems of projection with respect to the observer, object and the reference planes.
CO3	Construct orthographic views of an object when its position with respect to the reference planes is defined.
CO4	Analyse the internal details of an object through sectional views.
CO5	Analyse the details of an object through development of surfaces and intersection of surfaces
CO6	Develop 3D Isometric View from 2D orthographic views

Course Articulation Matrix:

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

Syllabus:

Introduction: Drawing instruments and their uses, Types of lines, Lettering, General rules for dimensioning, Geometrical constructions using instruments.

Orthographic Projection: Methods of projection, Principles of Orthographic projection, First angle versus third angle of projection, Six views of an object, Conventions.

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.

Development of Surfaces: Development of lateral surfaces of right solids – cube, prisms, cylinders, pyramids, cones.

Intersection of surfaces: Methods of determining the line of intersection between surfaces of two interpenetration solids in simple positions – Intersection of two prisms, two cylinders, cylinder and prism, cone and cylinder, cone and prism, two cones.

Isometric Views: Isometric axes, Isometric lines, Isometric Planes, Isometric scale, Isometric Views, Isometric projections.

Conversion of Views: Missing lines and missing views, Identification of planes, Conversion of isometric views into orthographic views. (Self-Study)

Learning Resources:

Text Books:

1. Engineering Graphics, N.D. Bhatt and V.M. Panchal, Charotar Publishers, 2016, 53rd edition.

Reference Books:

1. Engineering Drawing, Agarwal, B, McGraw Hill Education, 2015, Second edition.

Course Code: ME104	WORKSHOP PRACTICE	Credits 0-0-3: 1.5

Pre-Requisites: NIL

Course Outcomes:

CO1	Identify workshop tools and their operational capabilities
CO2	Practice on manufacturing of components using workshop trades including fitting, carpentry, foundry and welding
CO3	Apply suitable tools for machining processes including turning, facing, thread cutting and tapping
CO4	Apply basic electrical engineering knowledge for House Wiring Practice

Course Articulation Matrix:

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

Syllabus:

Demonstration: Safety practices and precautions to be observed in workshop.

Fitting Trade: Demonstration and practice of fitting tools, Preparation of T-Shape, Dovetail Joint.

Carpentry: Demonstration and practice of carpentry tools, Preparation of Cross Half lap joint and Mortise Tenon Joint.

Plumbing: Demonstration and practice of Plumbing tools, Preparation of Pipe joints with coupling for same diameter and with reducer for different diameters.

Machine shop: Demonstration and practice on Lathe Machine, Preparation of work pieces involving Facing, Plane Turning, step turning, knurling and parting operations.

House Wiring: Demonstration and practice on Electrical tools, wiring and earthing, Exercises on Staircase Wiring & Godown wiring.

Power Tools: Demonstration and practice on Power tools (Bosch Power Tools) and Safety Practices.

Foundry Trade: Demonstration and practice on Moulding tools and processes, Preparation of Green Sand Moulds for given Patterns.

Welding Shop: Demonstration and practice on Arc Welding and Gas welding. Preparation of Lap joint and Butt joint.

Learning Resources:

Text Books:

1. Basic Workshop Technology: Manufacturing Process, Felix W.; Independently Published,2019.
2. Workshop Processes, Practices and Materials; Bruce J. Black, Routledge publishers, 5th Edn. 2015.
3. A Course in Workshop Technology Vol I. & II, B.S. Raghuwanshi, Dhanpath Rai & Co., 2015 & 2017.

Reference Books:

1. Elements of Workshop Technology, Vol. I by S. K. Hajra Choudhury & Others, Media Promoters and Publishers, Mumbai. 2007, 14th edition
2. Elements of Workshop Technology, Vol. II by S. K. Hajra Choudhury & Others, Media Promoters and Publishers, Mumbai. 2007, 12th edition
3. Workshop Practice by H. S. Bawa, Tata-McGraw Hill, 2004.
4. Technology of machine tools, Steve F. Krar, Arthur R. Gill and Peter Smid, McGraw Hill Education (India) Pt. Ltd., 2013.
5. Engineering Practices Laboratory Manual, Ramesh Babu.V., VRB Publishers Private Limited, Chennai, Revised edition, 2013 – 2014.
6. Engineering Practices Lab Manual; T.Jeyapoovan, Vikas Pub, 4th Edn.2008.
7. Mechanical Workshop Practice; John K.C., PHI, 2010.
8. Wiring Estimating, Costing and Contracting; Soni P.M. & Upadhyay P.A.; Atul Prakashan, 2021-22.

Online Resources:

1. Different Trade E-Books (Fitting, Plumbing, Welding, Carpentry, Foundryman, Turner and House Wiring etc.) developed by National Instructional Media Institute, Chennai. Directorate General of Training, Ministry of Skill Development & Entrepreneurship, Govt. of India. (https://bharatskills.gov.in).

Course Code: CY136	CHEMISTRY LABORTORY FOR MECHANICAL ENGINEERING	Credits 0-0-2: 1

Pre-Requisites: NIL

Course Outcomes:

CO1	Select a suitable methodology for the estimation of metal content, iodine content, active chlorine or hardness of water
CO2	Analyze acids, bases, redox compounds using instrumental methods
CO3	Determine the corrosion inhibitor efficiency of selective compounds and process

Course Articulation Matrix:

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

List of Experiments:

1. Determination of Iron in Hematite.
2. Chemistry of Blue Printing.
3. Determination of Heat of Solution.
4. pH metric Titration of acid vs Base.
5. Conductometric titration of Acid vs Base.
6. Potentiometric Titration of an Acid vs Base.
7. Determination of Isoelectric point of an amino acid.
8. Determination of Rate of Corrosion of Mild Steel in Acidic Environment in the Absence and Presence of Inhibitor.
9. Synthesis of CdS nanomaterial.
10. Preparation of Phenol-formaldehyde resin.
11. Preparation of Polyaniline/Polypyrrole
12. Determination of Concentration of a colored compound using colorimetry.

Learning Resources:

Text Books:

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

I Year, II Semester

Course Code: MA183	INTEGRAL CALCULUS AND NUMERICAL METHODS	Credits 3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Evaluate multiple integrals in various coordinate systems
CO2	Apply the concepts of gradient, divergence and curl to formulate engineering problems
CO3	Convert line integrals into surface integrals and surface integrals into volume integrals
CO4	Interpret an experimental data using interpolation / curve fitting
CO5	Solve algebraic/transcendental equations and ordinary differential equations numerically

Course Articulation Matrix:

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

Syllabus:

Integral Calculus: Beta and Gamma integrals; Double and Triple integrals - computation of surface areas and volumes; change of variables in double and triple integrals.

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; Stoke's theorem; Gauss Divergence theorem

Numerical Methods: Curve fitting by the method of least squares. Fitting of (i) Straight line (ii) Second degree parabola (iii) Exponential curves. Gauss-Seidel iteration method to solve a system of equations and convergence (without proof). Numerical solution of algebraic and transcendental equations by Regula-Falsi method, Newton-Raphson method; Lagrange interpolation, Newton's divided differences, Forward, backward and central differences, Newton's forward and backward interpolation formulae, Gauss's forward and backward interpolation formulae, Numerical differentiation at the tabulated points with forward backward and central differences; Numerical Integration with Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule and Romberg integration; Taylor series method, Euler's method, modified Euler's method, Runge-Kutta method of 2^{nd} & 4^{th} orders for solving first order ordinary differential equations

Learning Resources:

Text Books:

1. Advanced Engineering Mathematics, R. K. Jain and S. R. K. Iyengar, Narosa Publishing

House, 2016, 5th edition.
2. Advanced Engineering Mathematics, Erwin Kreyszig, John Wiley and Sons, 2015, 8th edition.
3. Calculus and Analytic Geometry, George B. Thomas and Ross L. Finney, Pearson, 2020, 9th edition.

Reference Books:

1. Advanced Engineering Mathematics, Dennis G. Zill, Jones & Bartlett Learning, 2018, 6th edition.
2. Higher Engineering Mathematics, B. S. Grewal, Khanna Publishers, 2012, 42nd edition.

Course Code: PH181	PHYSICS FOR MECHANICAL ENGINEERING	Credits 2-0-0: 2

Pre-Requisites: NIL

Course Outcomes:

CO1	Apply the concepts of wave and particle nature of energy for solving problems radiant energy
CO2	Identify the applications of Interference, diffraction, optical fibers, holography and lasers in Industry
CO3	Identify the application of ultrasonic waves in engineering
CO4	Understand magnetism, superconductivity and identify their applications in mechanical engineering

Course Articulation Matrix:

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

Syllabus:

Quantum Mechanics: Concepts and experiments that led to the discovery of Quantum Nature, Heisenberg uncertainty principle; Schrodinger time independent and time dependent wave equations, the free particle problem, Particle in an infinite and finite potential well, Quantum mechanical tunneling.

Interference and Diffraction: Concept of interference, working of Michelson Interferometer, Fabry-perot Interferometer and its application as wavelength filter. Diffraction at Single, Double, Multiple slits, Application of Grating as wavelength splitter.

Polarization: Production and detection of polarized light, principles, Working and applications of Wave Plates, Laurent's Half Shade Polarimeter, Photo elasticity-Polariscopes and Engineering Applications.

Lasers: Basic theory of Laser, Fundamentals of lasers, Construction and working of He-Ne, Nd-YAG, CO2 Lasers - Welding, drilling, cutting, Holography and HNDT.

Optical Fibers: Structure, Types, Features, Light guiding mechanism and applications in Sensing.

Solar Cells: Solar spectrum, photovoltaic effect, materials, structure and working principle, I-V characteristics, power conversion efficiency, quantum efficiency, applications.

Magnetism and superconductivity: Introduction - Weiss Theory of Ferromagnetism – Properties – Domains - Curie Transition Hard and soft magnetic materials – Fundamentals of Superconductivity-properties-Meissner effect - Type-I and Type-II Superconductors – Applications.

Ultrasonics: Types of ultrasonic waves, ultrasonic velocities in different materials (solids, fluids and tissue), detection of ultrasonic signal, ultrasonic waves in Non-Destructive Testing

(NDT) of materials, applications of ultrasonic waves or sensors in Engineering and Bio-medical industries (temperature, distance measurements, SHM, ultrasound scanning, etc).

Learning Resources:

Text Books:

1. Fundamentals of Physics, Halliday, Resnic and Walker, John Wiley, 2011, Ninth edition.
2. Concepts of Modern Physics, Arthur Beiser, Shobhit Mahajan, S. Rai Choudhury, McGraw Hill Publications, 2009, Sixth edition.
3. Engineering Physics, Shatendra Sharma, Jyotsna Sharma, Pearson Education, 2018.

Reference Books:

1. Optics, Ajoy K. Ghatak, Tata McGraw Hill, 2017, Sixth edition.
2. Understanding Lasers An Entry-Level Guide, Jeff Hecht, Wiley Publications, 2018, Fourth edition.
3. A Text Book of Engineering Physics, M.N. Avadhanulu, P.G. Khirsagar, 2011, 9th edition.
4. University Physics with modern physics, Hugh D. Young,Roger A. Freedman Pearson Education, 2014.

Online Resources:

1. https://nptel.ac.in/courses/122/107/122107035/

Course Code: HS181	COMMUNICATION SKILLS AND REPORT WRITING	Credits 2-0-2: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Develop the purpose, goal of writing and speech, and an approach of persuading the audience
CO2	Order and structure the material and the flow of information to support argument in speech and writing
CO3	Create a report outline linking all the sections of a message
CO4	Present experimental data using the principles of statistical analysis
CO5	Edit technical documents for maximum impact by efficiently structuring the data and avoiding common written English mistakes

Course Articulation Matrix:

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

Syllabus:

Defining the Features of Technical Writing & Presentations: Principles and Strategies of Technical Report, Knowing Your Audience, Purpose and Length of Report, Understand the cornerstones of a presentation, Define the various purposes of presentations and plan the correct structure.

Plan and Structure- Writing & Speaking with Purpose: Headings, Chapters and sections, Running headers and footers, Types of reports and templates to use, Main Idea and Arranging Details in Logical Sequence, Writing styles & techniques, Focus on your audience's needs, Word choice, tone, and what to include.

Audience Awareness & Editing to contexts: Use correct grammar and punctuation to avoid common errors in reports & oral presentations, Create a professional, readable and visually attractive report & oral presentation, Follow a three-step editing process.

Style of Writing & Use of Graphics: Writing Clear Sentences and paragraphs, Remove Jargon, Redundancy and Wordiness, Kinds of graphics and their messages, Suitability for placement in a graphic representation.

Group Practice and Interactive Session: Spotting common language problems (lengthy and confusing sentence structures, weak vocabulary, etc), Editing Content, Logic and Language in speech & writing, Guided writing practice with examples (Participants are to bring along their reports for group learning, editing and discussion), Drafting – the mindset to avoid writer's block, Checking your own reports and presentations, Giving and receiving constructive feedback – what makes a review effective?

From Written Report to Verbal Presentation: Gather, analyse, organise and deliver technical information meaningfully, Use rhetorical devices and elements of persuasion to engage your audience.

Learning Resources:

Text Books:

1. Dynamic presentations, Powell, M., Student's book with audio CDs. Germany: Cambridge University Press, 2011.
2. In Company 3.0: Upper Intermediate, Allison, J., Powell, M. Germany: Macmillan, 2014.

Reference Books:

1. Professional Report Writing, Mort, S., United Kingdom: Taylor & Francis, 2017.
2. Technical Communication, Meenakshi Raman & Sangeeta Sharma, Oxford University Press.
3. Effective Communication Skills, Kulbushan Kumar, Khanna Publishing House, Delhi.
4. Communication Skills, Pushplata, Sanjay Kumar, Oxford University Press.

Online Resources:

1. Excelsior Online Writing Lab - https://owl.excelsior.edu/esl-wow/
2. The Purdue Writing Lab Resources - https://owl.purdue.edu/
3. Queen's University Student Academic Service Sources (SASS) - https://sass.queensu.ca/onlineresource/topics/#WC
4. Boise State University opensource textbook on Technical Communication - https://boisestate.pressbooks.pub/anintroductiontotechnicalcommunication/front-matter/introduction/

Course Code: CE101	ENGINEERING MECHANICS	Credits 3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Determine the resultant force and moment for a given system of forces
CO2	Analyze planar and spatial systems for determining the forces in members of trusses, frames and problems related to friction
CO3	Calculate the motion characteristics of a body subjected to a given force system
CO4	Determine the deformation of a shaft and identify the relationship between different material constants
CO5	Determine the centroid and second moment of area

Course Articulation Matrix:

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

Syllabus:

Introduction: Specification of force vector, Formation of Force Vectors, Moment of Force – Cross product – Problems, Resultant of a general force system in space, Degrees of freedom - Equilibrium Equations, Kinematics – Kinetics – De' Alemberts principle, Degree of Constraints – Free body diagrams.

Spatial Force systems: Concurrent force systems - Equilibrium equations – Problems, Problems (Vector approach) – Tension Coefficient method, Problems (Tension Coefficient method), Parallel force systems - problems, Center of Parallel force system – Problems.

Coplanar Force Systems: Introduction – Equilibrium equations – All systems, Problems on Coplanar Concurrent force system, Coplanar Parallel force system, Coplanar General force system – Point of action, Method of joints, Method of sections, Method of sections, Method of members, Friction – Coulombs laws of dry friction – Limiting friction, Problems on Wedge friction, Belt Friction-problems.

Mechanics of Deformable Bodies: Stress & Strain at a point- Normal and shear stresses, Axial deformations – Problems on prismatic shaft, tapered shaft and deformation due to self-weight, Deformation of Stepped shaft due to axial loading, Poisson's Ratio – Bulk Modulus - Problems, change in dimensions and volume.

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

Dynamics of Particles: Rectilinear Motion – Kinematics Problems, Kinetics – Problems, Work & Energy – Impulse Moment, Curvilinear Motion – Normal and tangential components.

Learning Resources:

Text Books:

1. Engineering Mechanics (In SI Units), S. Timoshenko, D.H. Young, J.V. Rao and Sukumar Pati, McGraw Hill Publishers, 2017,5th edition.
2. Vector Mechanics for Engineers - Statics and Dynamics, Ferdinand P. Beer, E. Russell Johnston Jr., et al., McGraw Hill Publishers, 2019, 12th edition.
3. Mechanics of Materials, Gere and Timoshenko, CBS Publishers, 2011, 2nd edition.

Reference Books:

1. Mechanics of Materials (SI edition), R. C. Hibbeler, Pearson publication, 2018.
2. Engineering Mechanics: Statics, SI Version, J. L. Meriam, L. G. Kraige, et al., Wiley India edition, 2017
3. Engineering Mechanics: Dynamics, SI Version, J.L. Meriam , L.G. Kraige, et al., Wiley India edition, 2018
4. Engineering Mechanics, S S Bhavikatti, New Age International Private Limited, 2021, 8th edition.

Online Resources:

1. NPTEL Lectures: https://nptel.ac.in/courses/122/104/122104015/, https://nptel.ac.in/courses/112/106/112106180/

Course Code: ME151	DESIGN STUDIO	Credits 0-0-3: 1.5

Pre-Requisites: NIL

Course Outcomes:

CO1	Express Product Design Ideas using 2D or 3D sketches
CO2	Model the components with geometric specifications and appropriate materials
CO3	Develop prototype of the product
CO4	Evaluate the entire product

Course Articulation Matrix:

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

Syllabus:

Sketching: 2D and 3D sketching: Students will sketch the concept on drawing sheets/ digital screens. The drawings will contain the specifications of the geometric form.

3D Modelling: Develop the 3D model features including free form surfaces, final product design specifications, Parametric design.

Physical Component Development: Development of components: fabrication of actual components of the product using the materials and tools available in the lab, Iterations.

Iterative improvement of the product and Report writing: Development of assemblies/mock-up models/ working models/ prototypes/functional models/products, Testing and design review, Report writing.

Learning Resources:

Text Books:

1. The design studio method: creative problem solving with UX sketching, Sullivan, Brian, Focal Press, 2016.
2. Autodesk Fusion 360 Black Book, Verma G., CADACAMCAE Works, 2021, 2nd edition.

Online Resources:

1. Self-Paced Tutorials https://help.autodesk.com/view/fusion360/ENU/courses/
2. Product Documentation https://help.autodesk.com/view/fusion360/ENU/?guid=GUID-1C665B4D-7BF7-4FDF-98B0-AA7EE12B5AC2

Course Code: ME152	KINEMATICS OF MACHINERY	Credits 3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Understand the principles of kinematic pairs, chains and their classification, degree of freedom, 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	Design suitable gears for the given application
CO5	Synthesize cams and followers for specified motion profiles

Course Articulation Matrix:

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

Syllabus:

Introduction to Mechanisms: Basic terminology, kinematic chains, Mechanisms, Degrees of freedom, Four bar chain - equivalents, inversions and their applications. Case studies on Straight line mechanisms, steering gear mechanisms and other general mechanisms.

Kinematic Analysis of Planar Mechanisms: Position analysis of single degree of freedom mechanisms, range of motion, extreme positions, transmission angle and quick return ratio. Building blocks for Velocity and Acceleration analysis- sliding pair, turning pair and turn slide pair. Graphical and Analytical methods for the velocity and acceleration analysis of four bar, slider crank and other single degree of freedom mechanisms.

Synthesis of Mechanisms: Dimensional synthesis, function generation, path generation and motion generation, Synthesis of single degree freedom closed loop mechanisms for specified Instantaneous conditions. Identification of available number of equations, input and output variables, design parameters and choice of free variables/parameters. Well-defined under-constrained and over-constrained mechanism synthesis.

Gears and Gear trains: Classification, Terminology, Law of Gearing, Interference and methods to avoid interference in spur gears. Simple, compound, reverted and cycloidal gear trains.

Cams: Classification of cams and followers, applications, SVAJ (Plot position (s), velocity (v), acceleration (a) and jerk (j) versus cam angle) diagrams. Overview of motion programs and synthesis of cam profiles.

Learning Resources:

Text Books:

1. Design of Machinery: An introduction to Synthesis and Analysis of Mechanisms and Machines, Norton, R.L., McGraw Hill International editions, New York, 2019, 6th edition.

Reference Books:

1. Theory of Mechanisms and Machines, Amitabha Ghosh and Ashok Kumar Mallik, East West Press Pvt. Ltd., New Delhi, 2017, 3rd edition.
2. Theory of Machines, S.S. Rattan, McGraw-Hill Publications, New Delhi, 2017, 3rd edition.
3. Theory of Machines and Mechanisms, Shigley J. E. and John Joseph Uicker, McGraw-Hill international edition, 2014, 2nd edition.
4. Machines and Mechanisms: Applied Kinematic Analysis, David H Myshka, Pearson, 2011, 4th edition.
5. Kinematics, Dynamics and Design of Machinery, Kenneth J Waldron, Gary L Kinzel, Wiley India Pvt Ltd, 2007, 2nd edition.

Course Code: ME153	ENGINEERING COMPUTATION LABORATORY	Credits 0-0-2: 1

Pre-Requisites: NIL

Course Outcomes:

CO1	Develop code for visualization and plotting using MATLAB
CO2	Develop programs in MATLAB to solve problems involving loops, functions and scripts
CO3	Develop code for solving mathematical models involving linear equations, nonlinear equations and Ordinary Differential Equations
CO4	Apply features of MATLAB and Python programming for numerical computations in engineering

Course Articulation Matrix:

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

Syllabus:

Matlab:

1. Introduction to MATLAB.
2. Practice session on handling basic arithmetic etc.
3. Writing codes with control loops, functions and scripts.
4. Developing codes for visualization and plotting.
5. Solving problems involving linear and nonlinear equations.
6. Solving problems involving curve fitting and interpolations.
7. Solving problems involving ordinary differential equations.

Python:

8. Practice programs using different types of variables and expressions.
9. Practice programs using loops and iterations.
10. Practice programs using conditional code, and functions.

Case-Study:

11. Case study with application of MATLAB /Python programming for topics from Engineering Mechanics.
12. Case study with application of MATLAB /Python programming for topics from Kinematics of machinery.

Learning Resources:

Text Books:

1. Applied Numerical Methods with MATLAB for Engineers & Scientists, Steven Chapra, McGraw-Hill, 2018, 4th edition.
2. Python for Everyone, Cay S. Horstmann, Rance D. Necaise, Wiley, 2019, 3rd edition.

Course Code: PH182	PHYSICS LABORATORY FOR MECHANICAL ENGINEERING	Credits 0-0-2: 1

Pre-Requisites: NIL

Course Outcomes:

CO1	Understand the use of lasers and optical instruments for experimentation
CO2	Apply the concepts of interference, diffraction, and polarization in engineering measurements
CO3	Demonstrate quantum nature of radiation using photoelectric effect
CO4	Determine acceptance angle and numerical aperture of an optical fiber

Course Articulation Matrix:

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

List of Experiments:

1. Determination of Wavelength of Sodium light using Newton's Rings.
2. Determination of Wavelength of He-Ne laser - Metal Scale.
3. Measurement of Width of a narrow slit using He- Ne Laser.
4. Determination of Specific rotation of Cane sugar by Laurent Half-shade Polarimeter.
5. Determination of Numerical aperture, loss, Acceptance angle of optical fiber.
6. Determination of plank constant by photo electric effect.
7. Determination of I – V characteristics of photo diode.
8. Diffraction grating by normal incidence method.

Learning Resources:

Text Books:

1. Physics Laboratory Manual by Physics Department, NIT Warangal, 2021.
2. Practical Physics by P.R. Sasi Kumar, PHI publications, first edition, 2011

Reference Books:

1. Practical Physics by G.L. Squire, Cambridge University press, fourth edition, 2001.
2. Engineering Physics Practical by Dr.S.K. Gupta Krishna Prakashan Publications, ninth edition, 2010

Online Resources:

1. NPTEL Courses: https://nptel.ac.in/courses/115/105/115105110
2. Amrita virtual labs.

II Year, I Semester

Course Code: MA233	TRANSFORMATION TECHNIQUES AND STATISTICS	Credits 3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Obtain the Fourier series for a given function
CO2	Find the Fourier transform of a function
CO3	Determine the solution of a PDE by variable separable method
CO4	Understand the concepts of probability and statistics
CO5	Perform testing of hypothesis

Course Articulation Matrix:

	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		1	1							1	2	1
CO5	3	2		1	1							1	1	1

1 - Slightly; 2 - Moderately; 3 - Substantially

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: Fourier Series Solutions of Wave equation, Heat equation and Laplace's equation by the method of separation of variables

Statistics and Probability: Review of fundamental concepts of probability, Moments and Moment generating function of Discrete and continuous distributions, Binomial, Poisson, Normal distributions and central limit theorem, fitting these distributions to the given data, Hypothesis testing: comparison of single mean to specified value and comparison of equality of two means, Comparison of one variance to a specified value, comparison of two variance, Chi-square test for goodness of fit. - Correlation, ANOVA for testing equality of multiple means.

Learning Resources:

Text Books:

1. Advanced Engineering Mathematics, R. K. Jain and S. R. K. Iyengar, Narosa Publishing House, 2016, Fifth Edition
2. Advanced Engineering Mathematics, Erwin Kreyszig, John Wiley and Sons, 2015, Eighth Edition

Reference Books:

1. Advanced Engineering Mathematics, Dennis G. Zill, Jones & Bartlett Learning, 2018, Sixth Edition
2. Miller & Freund's Probability and Statistics for Engineers, Richard A. Johnson, Pearson, 2018, Ninth Edition

Course Code: MM235	MATERIALS ENGINEERING	Credits 3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Understand the crystal structure and constitution of alloys
CO2	Choose 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, alloys, ceramics, polymers and composites
CO5	Identify the forms of corrosion and suggest methods to prevent it

Course Articulation Matrix:

	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

1 - Slightly; 2 - Moderately; 3 - Substantially

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: Introduction, properties and applications of ceramics, polymers and composites.

Corrosion and Corrosion Protection: Corrosion- significance, EMF and galvanic corrosion, Major forms of corrosion - uniform, two-metal, crevice, pitting, erosion corrosion,

environmentally induced cracking, Corrosion testing- gravimetric analysis and electrochemical methods, Influence of microstructure on corrosion resistance, and remedial passivation methods

Learning Resources:

Text Books:

1. Materials Science and Engineering, W.D. Callister (Adapted by R. Balasubramaniam), Wiley India, New Delhi, 2014 and 2nd Edition
2. Introduction to Physical Metallurgy, S. H. Avner, McGraw-Hill Education Publishers, New York, USA, 1997 and 2nd Edition
3. Physical Metallurgy: Principles and Practice, V. Raghavan, Prentice Hall of India Learning Pvt. Ltd., Delhi, 2012 and 2nd Edition

Reference Books:

1. Engineering Materials 1 - An Introduction to Properties, Applications and Design, M.F. Ashby and D.R.H. Jones, Butterworth-Heinemann Publishers, Massachusetts, USA, 2011 and 4th Edition
2. Engineering Materials 2 - An Introduction to Microstructures and Processing, M.F. Ashby and D.R.H. Jones, Butterworth-Heinemann Publishers, Massachusetts, USA, 2012 and 4th Edition
3. Materials Science and Engineering: A First Course, V. Raghavan, Prentice Hall of India Learning Pvt. Ltd., Delhi, 2015 and 6th Edition
4. Physical Metallurgy for Engineers, D.S. Clark and W. Varney, CBS Publishers and Distributors, New Delhi, 2004 and 2nd Edition

Course Code: CE231	MECHANICS OF SOLIDS	Credits 3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Distinguish statically determinate and indeterminate problems
CO2	Determine the resistance and deformation in machine members subjected to axial, flexural and torsional loads
CO3	Apply the concept of failure theories for design
CO4	Analyse and design thin, thick cylinders and springs

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

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 and Thick Cylinders: Thin and Thick 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.

Deflection of Beams: Slope and deflection of beams - Double Integration method - Macaulay's method - strain energy method.

Springs: Axial load and torque on helical springs - stresses and deformations - strain energy - compound springs - leaf springs.

Learning Resources:

Text Books:

1. Mechanics of Materials, Timoshenko and Gere, CBS Publishers, 2011, 2nd Edition
2. Engineering Mechanics of Solids, E.P.Popov, Pearson, 2015, 2nd Edition
3. Mechanics of Structures, S. B. Junarkar, Charotar Publishers, 2012

Reference Books:

1. Strength of Materials - Pytel & Singer, Harper & Row Publishers, 2018, 4th Edition.
2. Advanced Mechanics of Solids, L.S Srinath, McGraw Hill Education, 2017, 3rd Edition.
3. Mechanics of Materials, Beer and Johnston, McGraw Hill India Pvt. Ltd., 2020, 8th Edition (SI Units).

Online Resources:

1. https://nptel.ac.in/courses/112/102/112102284/
2. https://nptel.ac.in/courses/105/105/105105108/
3. https://nptel.ac.in/courses/105/106/105106172/

Course Code: CE232	FLUID MECHANICS & HYDRAULIC MACHINES	Credits 3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Apply conservation laws to fluid flow problems in engineering applications
CO2	Design experimental procedure for studying physical models
CO3	Design the working proportions of hydraulic machines
CO4	Compute drag and lift coefficients using the theory of boundary layer flows
CO5	Design free surface and pipe flows
CO6	Solve one dimensional compressible fluid flow problems

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: Purpose of study of fluid mechanics for design and operation of engineering systems in the fields of Mechanical Engineering, Aeronautical Engineering, Metallurgical Engineering, Civil Engineering, Biomedical Engineering, Chemical Engineering. Fundamental difference between a solid and fluid, constituent relationships for solids and fluids, conservation principles applied in fluid mechanics

Review of physical meaning of Mathematics necessary for understanding of fluid mechanics, review of analogies in mass transfer and heat transfer

Description of fluid flow: with reference to translation, rotation and deformation concept of continuum, control mass & control volume approach, Reynolds transport theorem. Steady flow and uniform flow.

Velocity field, one & two-dimensional flow analysis, circulation and vorticity, stream function and velocity potential function, potential flow, standard flow patterns, combination of flow patterns, flow net.

Continuity equation, Euler's equation of motion, Bernoulli's equation, Impulse momentum equation and applications.

Dimensional Analysis as a tool in design of experiments, identification of non-dimensional numbers and their significance, dimensional analysis methods.

Equations of motion for laminar flow of a Newtonian fluid - Viscous flow - Navier-Stoke's equations, simple exact solutions for Hydrodynamic lubrication.

Boundary Layer Theory-Formation, growth and separation of boundary layer-Integral momentum principles to compute drag and lift forces-Mathematical models for boundary layer flows.

Turbulence, universal velocity distribution laws of turbulence, smooth rough and transitional turbulent flow in pipes, pipe resistance equation for pipes design of pipe networks, free surface flow.

Compressible flows- Isentropic flows - Adiabatic flow with friction - Frictionless flow with heat addition - Shock waves.

Principles of Hydraulic Turbines - Impulse and Reaction Turbines - Pelton Turbine - Francis Turbine - Kaplan Turbine, working principles, design principles.

Centrifugal pumps - Axial flow pumps, working principles, design principles.

Learning Resources:

Text Books:

1. Introduction to Fluid Mechanics, Robert W. Fax, Philip J. Pritchard, Alan T. McDonald. Wiley India Edition. (Wiley Student Edition), 2011, 7th Edition
2. Fluid Mechanics, Franck .M White, Tata McGraw Hill Publication, 2017, 8th Edition
3. Engineering Fluid Mechanics Equipments, K.L Kumar, Eurasia Publishing Home, 1997

Reference Books:

1. Mechanics of Fluids, Shames, McGraw Hill Book Co., New Delhi, 1988
2. Fluid Mechanics, Streeter V.L. and Benjamin Wylie, McGraw Hill Book Co., New Delhi, 1999.
3. Hydraulic Machines, Jagdish Lal, Metropolitan Book Co, Delhi, 1999

Course Code: EE235	BASIC ELECTRICAL AND ELECTRONICS ENGINEERING	Credits 2-0-0: 2

Prerequisites: NIL

Course Outcomes:

CO1	Analyze DC & AC circuits and determine power & power factor
CO2	Understand the construction and principle of operation of single-phase transformer
CO3	Understand the thermal power generation systems
CO4	Analyze basic electronic circuits and estimate the illumination requirements
CO5	Understand the working of digital instrumentation

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PS02
CO1	2	2	2			2	2					2	2	1
CO2	2	2	2			2	2					2	2	1
CO3	2	2	2			2	2					2	2	1
CO4	2	2	2			2	2					2	2	1
CO5	2	2	2			2	2					2	2	1

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

DC Circuits: Kirchoff's Voltage and Current Laws, Superposition Theorem, State-Delta Transformations.

AC Circuits: Complex representation of Impendence, Phasor diagrams, Power & Power Factor, Solution of 1-Phase Series & Parallel Circuits.

Single Phase Transformers: Principle of operation of a Single-Phase Transformer, EMF Equation, Phasor Diagram, Equivalent Circuits of a 1-Phase Transformer, Determination of Equivalent circuit parameters, calculation of regulation & Efficiency of a Transformer.

Thermal Power Generation Systems: Layout, 3-Phase generation, Plant load factor, Ramp-up, Ramp-down.

Electronics Devices & Circuits: P-type and N-type semiconductors, P-N junction diode and its I-V Characteristics, Single-phase Half wave and Full wave rectifiers, Bipolar Junction Transistor operation and CE, CC & CB amplifiers.

Illumination: Laws of illumination and luminance (Qualitative), LED lighting schemes.

Digital Instrumentation: Digital Multimeters, Transducers.

Learning Resources:

Textbooks :

1. Electrical & Electronic technology, Edward Hughes, Pearson Education, 2016, 12th Edition.
2. Electrical Engineering Fundamentals, Vincent Del Toro, Pearson Education, 2015, 2nd Edition.
3. Principals of Electrical & Electronics Engineering, V K Mehtha, S Chand Publications, New Delhi, 2010, 3rd Edition.

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

Reference:

1. Integrated Electronics – Analog and Digital Circuits and systems, Millman & Halkias, Tata McGraw-Hill Education, 2017, 2nd Edition.
2. Basic Electrical Engineering, U Bakshi & A Bakashi, Technical Publication, 2019.
3. Electrical Machines, A Fitzgerald, Charles Kingsley, Stephen Umana, McGraw Hill Education, 2017, 6th edition.
4. Electric Machinery, Stephen J Chapman, McGraw Hilll International Edition, 2017, 4th Edition.
5. Electric Machinery – Theory, Performance & Applications, P.S Bimnbra, Khanna Publishers, 2014, 7th edition.

Online resources:

1. www.neptel.com

Course Code: ME201	THERMODYNAMICS	Credits 3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Understand the concepts of continuum, system, thermodynamic properties, thermodynamic equilibrium, work and heat.
CO2	Apply the laws of thermodynamics to thermal machines.
CO3	Evaluate the ideal and real gas relations
CO4	Evaluate the quality of steam and properties of pure substances
CO5	Analyze air standard and vapour power cycles

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

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

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 rule, and numerical problems. First law applied to a control volume, general energy equation, steady flow energy equation on unit mass and time basis, application of SFEE for devices such as boiler, turbine, heat exchangers, pumps, nozzles, etc. Illustrative problems

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, Carnot cycle. 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, T-ds relations, available and unavailable energy, irreversibility, problems. Third law of thermodynamics, absolute entropy

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. Steam processes; expressions for the change in internal energy, enthalpy, work, heat, entropy in various processes, Mollier chart.

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, virial coefficients, compressibility factor, generalized compressibility chart, problems.

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

Vapor power cycles: Rankine cycle, illustrative problems and illustrative problems

Learning Resources:

Text Books:

1. Engineering Thermodynamics, P.K.Nag, McGraw Hill Education - 6th Edition, 2017
2. Fundamentals of Thermodynamics, G.J.Vanwylen and R.E.Sonntag, Wiley India Pvt. Limited, 7th Edition, 2009

Reference Books:

1. Basic Engineering Thermodynamics, A.Venkatesh, Universities Press- reprint, 2007
2. Thermodynamics: An Engineering Approach, Yonus A Cengel and Michale A Boles, McGraw Hill Education, 9th Edition 2019

Online Resources:

1. https://nptel.ac.in/courses/112/108/112108148/

Course Code: ME202	DYNAMICS OF MACHINERY	Credits 3-0-0: 3

Prerequisites: NIL

Course Outcomes:

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	Illustrate the gyroscopic effects in ships, aero planes and road vehicles.
CO5	Analyze centrifugal governors.

Course Articulation Matrix:

	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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Gyroscope: Principle of gyroscope, Roll, pitch and Yaw motions, Gyroscopic effect in Aeroplanes, Naval ships, Automobiles and two wheelers.

Dynamics analysis of Reciprocating systems and Flywheels: Dynamic analysis of reciprocating machines, turning moment diagrams, fluctuation of energy, design of flywheel for systems with prime mover and loading: fluctuation at the prime mover side, fluctuation at load side and fluctuation on both sides.

Balancing of Rotating systems: Unbalanced forces and Couples in rotating systems. Static and dynamic balancing of single plane and multi plane rotating systems. Overview of balancing machines and field balancing.

Balancing of Reciprocating systems: Primary and secondary balancing of single and multi-cylinder inline engines, V-engines and radial engines.

Vibrations: Mathematical modelling of single degree of freedom systems. Free and forced vibrations of single degree of freedom systems, case studies on rotating/reciprocating unbalances, whirling of rotors, transmissibility and vibration isolation.

Learning Resources:

Text Books:

1. Design of Machinery - An introduction to Synthesis and Analysis of Mechanisms and Machines, Norton, R.L., McGraw Hill International Editions, New York, 2000, 2nd Edition
2. Mechanical Vibrations, Venkatachalam, R., PHI, 2014.

Reference Books:

1. Theory of Machines and Mechanisms, Shigley, J.E., and Uicker, J.J., McGraw Hill Int. Edition, New York, 2003, 2nd Edition
2. Theory of Machines, S.S. Rattan, McGraw-Hill Publications, New Delhi, 2011, 3rd edition

Course Code: CE233	MATERIAL TESTING LABORATORY	Credits 0-0-2: 1

Pre-Requisites: NIL

Course Outcomes:

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

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 - Substantially

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 study the stress - strain characteristics of (a) Copper and (b) Aluminium by conducting tension test on Hounsfield Tensometer.
3. To find the Compressive strength of wood and punching shear strength of G.I. sheet by conducting relevant tests on HousfieldTensometer.
4. To find the Brinnell's and Vicker's hardness numbers of (a) Steel (b) Brass (c) Aluminium (d) Copper by conducting hardness test.
5. To determine the Modulus of rigidity by conducting Torsion test on (a) Solid shaft (b) Hollow shaft .
6. To find the Modulus of rigidity of the material of a spring by conducting Compression test.
7. To determine the Young's modulus of the material by conducting deflection test on a simply supported beam.
8. To determine the Modulus of elasticity of the material by conducting deflection test on a Propped Cantilever beam.
9. To determine the Modulus of elasticity of the material by conducting deflection test on a continuous beam.
10. Ductility test for steel.
11. Shear test on Mild Steel rods.

Learning Resources:

Text Books:

1. Material Testing Laboratory Manual by Civil Engineering Department, NIT Warangal, 2021.

Course Code: CE234	FLUID MECHANICS & HYDRAULIC MACHINES LABORATORY	Credits 0-0-2: 1

Pre-Requisites: NIL

Course Outcomes:

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

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 - Substantially

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. Measurement of Viscosity of water, SAE - 10 Oil by Hazen Poiseuille method and that of gleserene by Stoke's method.
5. Determination of Darcy Friction Factor, relative roughness for laminar and turbulent flows.
6. Determination of Manning's and Chezy's coefficients for smooth and rough channels by gradually varied flow method.
7. Application of momentum equation for determination of coefficient of impact of jets on flat and curved blades and Pelton bucket.
8. Determination of Energy loss in Hydraulic jump.
9. Computation of pressure drag coefficient for flow past a cylinder in a subsonic wind tunnel.
10. Performance Characteristics of single stage centrifugal pump, multi stage centrifugal pump.
11. Submersible pumps, and varying speed centrifugal pump.
12. Performance Characteristics of Pelton turbine, Francis turbine, and Kaplan turbine.

Learning Resources:

Text Books:

1. Engineering Fluid Mechanics, K.L.Kumar, Eurasia Publishing House, 2016
2. Hydraulic Machines including Fluidics, Jagdish Lal, Metropolitan Book Co, Delhi, 2016

Course Code: ME203	KINEMATICS AND DYNAMICS LABORATORY	Credits 0-0-2: 1

Pre-Requisites: NIL

Course Outcomes:

CO1	Analyze the kinematics of different mechanisms.
CO2	Analyze the frequency and time period of objects under free vibration
CO3	Analyze the mechanism of forced vibrations in terms of damping properties
CO4	Analyze the mechanism of forced vibration in terms of mode shapes and critical speed of shaft.

Course Articulation Matrix:

	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

1 - Slightly; 2 - Moderately; 3 - Substantially

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
4. To verify the natural frequency of a semi cylindrical shell resting on a horizontal surface.
5. To find the location of the center of mass G and the moment of inertia about IG of a given connecting rod (Compound pendulum).
6. To determine the viscous damping coefficient of a given viscous damper
7. To estimate the damping in given vibrating system through Logarithmic decrement.
8. To determine the viscous damping coefficient of a viscous damper by observing free vibrations of Spring-Mass-Damper system.
9. To determine the coefficient of friction between two surfaces.
10. 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
11. To determine the first and second natural frequencies of a Cantilever beam (Vibration of Continuous system)
12. To estimate the Critical speed of shafts
13. To determine imbalance and perform balancing operation using Balancing apparatus

Learning Resources:

Text Books:

1. Mechanical Vibrations, RV Chalam, 1st Edition PHI, 2014
2. Theory of Machines, S.S. Rattan, McGraw-Hill Publications, New Delhi, 2011, 3rd edition

Online Resources:

1. https://dom-nitk.vlabs.ac.in/List%20of%20experiments.html
2. http://va-coep.vlabs.ac.in/List%20of%20experiments.html?domain=Mechanical%20Engineering
3. https://www.gunt.de/en/products/engineering-mechanics-and-engineering-design/dynamics/glct-1:pa-148:ca-14

II Year, II Semester

Course Code: SM283	ENGINEERING ECONOMICS AND COSTING	Credits 3-0-0: 3

Prerequisites: NIL

Course Outcomes:

CO1	Compare the methods of economic analysis to evaluate a project viability
CO2	Evaluate different methods of depreciation.
CO3	Understand the macro-economic environment.
CO4	Analyse the financial statements with ratios for investment decisions.
CO5	Analyse costs and their role in pricing

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PS02
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		

1 - Slightly; 2 - Moderately; 3 – Substantially

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 using Pay back, ARR, NPV, IRR and B/C ratio. The Effect of borrowing on investment, Equity Vs Debt Financing, Concept of leverage, Income tax and leverage.
2. Depreciation and methods of calculating depreciation (Straight line, Sum of the years digit method, declining Balance Method, Annuity Method, Sinking Fund method).
3. National Income Accounting, Methods of Estimation, Various Concepts of National Income, Significance of National Income Estimation and its limitations.
4. Inflation, Definition, Process and Theories of Inflation and Measures to Control.
5. Balance of payments and its impact on exchange rate.
6. New Economic Policy 1991, LPG and its impact on Indian industry.
7. Basics of Union Budget, various deficits such as fiscal deficit and revenue deficit.

Accountancy and Costing

1. Basic concepts of accounting, financial statements: Trial balance, income statements and balance sheet, Ratio analysis.
2. Cost accounting, classification of costs, cost sheet and preparation of cost sheet, break even analysis and sensitivity analysis.

Learning Resources:

Text Books:

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

4. Cost Accounting, Arora, M.N., Vikas Publication, 2013

Online Resources:

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

Course Code: EE281	ELECTRICAL MACHINES AND CONTROLS	3-0-2: 4

Prerequisites: NIL

Course Outcomes:

CO1	Understand the construction and principles of operation of electrical machines
CO2	Understand electrical drive mechanism and methods of energy conservation
CO3	Apply power electronic converters to control the speed of DC motors and induction motors
CO4	Understand electric vehicle topologies
CO5	Evaluate performance characteristics of electrical machines and drives

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PS02
CO1	3	3	2				1						3	2
CO2	3	3	2				1						3	
CO3	3	3	2				1						2	
CO4	3	3	2				1						2	
CO5	3	3	2				1						2	

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

DC Machines: Principle of Operation, Classification, EMF and Torque Equations, Characteristics of 3-Phase Induction Motor & Applications.

AC Machines: 3-Phase Induction Motor- Principle of Operation, Torque-Speed Characteristics of 3-Phase Induction Motor & Applications.

Introduction to electric drives: Advantages of Electric drives, Parts of Electrical Drives, Electric Motors, Power Modulators, Sources, Choice of Electric Drives and selection of drives for various applications.

Dynamics of electrical drives: Fundamental torque equation, components of load torque, speed-torque characteristics of loads. Equivalent values of drive parameters, loads with rotational motion, loads with translational motion. Basic principles of closed-loop control.

Control of dc motor drives: Conventional speed control methods, speed control of dc motors using single-phase fully controlled, chopper-controlled drives.

Power electronic control of electric vehicles: Speed control of electric vehicles with 1-single phase and 3-phase voltage source inverters with sine-triangle pulse width modulation techniques.

Control of induction motor drives: Speed control of induction motor using stator voltage control, variable voltage and variable frequency control using voltage source inverter (VSI).

Motors for modern electric vehicles: Introduction to special machines, speed control methods of Switched reluctance motor drive (SRM), Permanent magnet synchronous motor (PMSM) - Brushless Direct current (BLDC) machine control strategies– Application.

Electric vehicle topologies: Series, parallel, series-parallel, complex hybrid vehicles.

List of Laboratory Experiments

1. Measurement of active and reactive power in 1 Phase and 3-Phase circuits
2. Speed control of DC motor using field control and armature voltage control method
3. 3-Phase Induction motor performance characteristics
4. Speed control of DC motor using single phase fully controlled drives
5. Speed control of electrical vehicles
6. Speed control of switched renitence motor drives
7. Performance characteristics of 1 Phase transformer
8. Performance characteristics of 3 Phase A.C generator.
9. Comparison of the performance CFL and LED lamps.

Learning Resources:

1. G.K. Dubey: Fundamentals of Electric Drives –Narosa Publishers, Second edition, 2007.
2. S.B. Dewan, G.R. Slemom, A. Straughen: Power semiconductor drives, John Wiley &Sons.
3. VedamSubramanyam: Electric Drives Concepts & Applications –Tata McGraw Hill Edn. Pvt.Ltd, Second Edition, 2011.
4. Werner Leonhard: Control of Electric Drives, Springer international edition2001.
5. Modern Power Electronics & AC Drives – B.K. Bose, Pearson, First edition
6. Electric Motor Drives: Modeling, Analysis and Control – R. Krishnan – Prentice Hall

Course Code: ME251	MANUFACTURING SCIENCE	Credits 3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Design core, core print and gating system in metal casting processes.
CO2	Design near net shaped components from metal and ceramic powders
CO3	Examine weld joints fabricated through solid state and fusion joining, brazing and soldering techniques
CO4	Develop process-maps for metal forming processes using plasticity principles

Course Articulation Matrix:

	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	3	3	3	2	2	2	2						3	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to Manufacturing, Net and near-net shape manufacturing and their evolution

Near-Net and Net Shaped Manufacturing:

Casting: Introduction, Types of different Casting Methods, Solidification of Alloys and its mechanism, Gating System Design and Estimation of Solidification time, Riser Design and Riser Placement, Process Variations, Defects and Remedies. Problems on casting

Powder Metallurgy: (Metals and Ceramics) Techniques of near net shape manufacturing, techniques of powder manufacturing, powder compaction methods, introduction to sintering, Sintering phenomenon, post sintering operations. Problems on sintering

Joining Processes: Physics of Welding - Types of welding - Fusion and Solid-state welding processes- - Solidification Phenomenon in Welding – Microstructural Evolution – Different Zones of Weld Region and their Microstructural Evolution - Brazing and Soldering, Defects and Remedies - Problems on welding

Deformation Processes:

Metal Forming: Introduction, Types of Forming Methods - Bulk and Sheet, Mechanism of plastic deformation, 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. Problems on forming.

Learning Resources:

Text Books:

1. Manufacturing Science. Amitabha Ghosh and Mallick A. K, Affiliated East-West Press Pvt. Ltd. 2010.
2. Science and Engineering of Casting Solidification, Doru Michael Stefanescu, Springer, 2009
3. Welding Metallurgy, Sindo Kao, 2nd Edition, Wiley, 2002.
4. Fundamentals of Manufacturing Process, G. K. Lal and S. K. Choudhury, 2009, CRC Press,

2011.
5. Powder Metallurgy- Science, Technology and Applications, P. C. Angelo and R. Subramanian, PHI, New Delhi, 2010.

Reference Books:

1. Materials and Processes, in Manufacturing, Paul Degarmo E, Black J.T and Ronald A. Kosher, Eight Edition, Prentice –Hall of India, 1997.
2. Solidification and Casting, Brian Cantor, Keyna O'Reilly, Taylor and Francis, 2002.
3. Formability of Metallic Materials: Plastic Anisotropy, Formability Testing, Forming Limits, Dorel Banabic, Springer, 2010.

Online Resources:

https://www.mooc-list.com/tags/manufacturing

Course Code: ME252	DESIGN OF MACHINE ELEMENTS	Credits 3-0-0: 3

Prerequisites: NIL

Course Outcomes:

CO1	Identify the preferred sizes and codes and selection of proper material for designing machine elements
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:

	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	2							2	2	1
CO4	3	3	3	2	2							2	2	1

1 - Slightly; 2 - Moderately; 3 - Substantially

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- key and 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, Eccentrically bolted joints in shear, Turnbuckle, Design of 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 in leaf springs, Nipping. Equalized stresses.

Learning Resources:

Text Books:

1. Mechanical Engineering Design. Richard G. Budynas, J Keith Nisbett, Shigley's. McGraw Hill, Ninth edition, 2011.
2. Design of Machine Elements, V B Bhandari, Tata McGraw Hill Education Private Limited, Third edition, 2012.

Reference Books:

1. Machine design an integrated approach., Robert L Norton, Pearson Education, Second edition, 2009.
2. Machine Design, Black and Adams, McGraw Hill and Co, New Delhi, 2002.
3. Machine Design, S G Kulkarni, Tata McGraw Hill, New Delhi, 2010.

Course Code: ME253	HEAT TRANSFER	Credits 3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Understand the basic modes of heat transfer
CO2	Compute temperature distribution in steady-state and unsteady-state heat conduction
CO3	Estimate heat transfer through forced and free convection
CO4	Calculate the radiation heat transfer in multi body enclosure
CO5	Design heat exchangers using LMTD and NTU methods.

Course Articulation Matrix:

	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

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 Coordinate Systems.

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

Boiling and Condensation: Basics of Pool Boiling, Flow Boiling, Film condensation and dropwise condensation

Learning Resources:

Text Books:

1. Fundamentals of Heat and Mass Transfer, Incropera, F. P. and De Witt, D. P., John Wiley and Sons, New York, 8th edition, 2019.
2. Heat Transfer, Holman, J. P., Bhattacharyya Souvik, Tata McGraw Hill, New Delhi, 10th edition 2017.

Reference Books:

1. Heat Transfer - A Basic Approach, M. Necati Ozisik, McGraw Hill, New York., 1985
2. Heat Transfer, Alan J. Chapman, Macmillan, New York, 4th edition, 2016.

Course Code: ME254	PRIME MOVERS FOR AUTOMOBILES	Credits 3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Compare the construction and working principle of IC engines on the basis of thermodynamic cycles and combustion process.
CO2	Estimate engine performance and emission parameters.
CO3	Identify harmful IC engine-out emissions and the viable alternate fuels.
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:

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction to IC engines: Classification of Prime Movers; IC Engines as Prime Movers; Historical Perspective of IC Engines; IC Engines-Classification, Mechanical cycle and Thermodynamic cycle, Air standard cycles-Diesel, Otto, Dual and Miller cycles. Differences between 2-stroke and 4-stroke cycle engines, Differences between SI and CI engines.

Combustion in SI and CI Engines: SI Engines: Brief treatment on Flame Propagation-Combustion phenomena (Normal and Abnormal), Factors affecting, Detonation, Ignition quality (Octane rating), Requirements of good combustion Chamber-Types, HUCR; **CI**

Engines: Importance of air motion and Compression Ratio, Mixture Preparation inside the CC. Normal and abnormal combustion - Ignition Quality (Cetane rating) ; Characteristics of a Good Combustion Chamber- Classification of Combustion Chambers (DI and IDI).

Fuel Metering in SI and CI Engines: Brief treatment on Carburetion and fuel injection systems for SI Engines; Types 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. Brief treatment on Measurement of engine emissions-instrumentation and 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. Engine and Chassis dynamometers, driving cycles, Factors affecting performance, Heat loss, Air-fuel ratio, Energy Balance: Pi and Sankey diagrams Numerical problems.

Alternate Fuels: Need for Alternate fuels, Desirable Characteristics of a good Alternate Fuel-Liquid and Gaseous fuels for SI and CI Engines, LPG, Alcohols, Bio-fuels, Natural Gas and Hydrogen. Brief treatment on production and use of alternate fuels in IC Engines.
Batteries: Battery: Battery parameters; Types of batteries- Technical characteristics-Ragone plots.
Electric Vehicles: Introduction: History of EVs, EV system, basic structure- Electric vehicle drive train-advantages and limitations, Components of EV Battery run EVs and Electric Motor run EVs- Brief treatment on types of electric machines for EVs (Power-Torque characteristics), regenerative braking system.
Hybrid Vehicles: Configurations of hybrids, advantages and limitations- basic structure of series, parallel and series-parallel configurations, Power-Torque characteristics. Hydrogen: Production-Hydrogen storage systems-reformers.
Fuel Cell vehicles: Introduction-Fuel cell characteristics, Fuel cell types: Brief introduction to PEMFC and DMFCs.

Learning Resources:

Text Books:

1. Internal Combustion Engine Fundamentals, John.B. Heywood , McGraw Hill Co.2018 II Edition.
2. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, Mehrdad Ehsani, Yimin Gao, Stefano Longo and Kambiz Ebrahimi, CRC Press, 2018 II Edition.

Reference Books:

1. Engineering Fundamentals of IC Engine, W.W. Pulkrabek , PHI Pvt.Ltd 2002 II Edition
2. Electric vehicle technology explained, John Lowry and James Larmine, John Wiley and Sons, 2012.
3. PEM Fuel Cells-Theory and Practice, Frano Barbir, Elsevier Academic Press, 2005.

Online Resources:

1. https://nptel.ac.in/courses/112/104/112104033/Engine Emissions-B.P.Pundir
2. https://nptel.ac.in/courses/108/103/108103009/ Introduction to Hybrid and Electric vehicles/Dr. Praveen Kumar and Prof. S. Majhi-IIT Guwahati

Course Code: ME255	HEAT TRANSFER AND FUELS LABORATORY	Credits 0-0-2: 1

Pre-Requisites: NIL

Course Outcomes:

CO1	Measure the 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 the working of a Heat Pipe.

Course Articulation Matrix:

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

Syllabus:

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.
4. **Two-Stage Reciprocating Air-Compressor:** Determination of volumetric efficiency of the compressor as a function of receiver pressure.
5. **Pin-Fin Apparatus:** Determination of temperature distribution, efficiency and effectiveness of the fin working in a forced convection environment.
6. **Natural Convection Apparatus:** Determination of experimental and empirical values of free convection heat transfer coefficient from a Heated Vertical Cylinder.
7. **Composite Slab Apparatus:** Determination of theoretical and experimental values of equivalent thermal resistance of a composite slab.
8. **Forced Convection Apparatus:** Determination of theoretical, experimental and empirical values of forced convection heat transfer coefficient for flow through a circular pipe.
9. **Emissivity Apparatus:** Determination of surface emissivity of a given test plate at a given absolute temperature.
10. **Heat Pipe Demonstrator**: Demonstration of isothermal characteristics exhibited by a heat pipe in comparison to other pipes.
11. **Parallel and Counter flow Heat Exchanger:** Determination of LMTD of parallel and counter flow heat exchanger.

Learning Resources:

Text Books:

1. Heat Transfer - A Basic Approach, M. Necati Ozisik, McGraw Hill, New York., 1985
2. Fundamentals of Heat and Mass Transfer, Incropera, F. P. and De Witt, D. P., John Wiley and Sons, New York, 8th Edition, 2019

Reference Books:

1. Heat Transfer, Holman, J. P., Bhattacharyya Souvik, Tata McGraw Hill, New Delhi, 10th edition 2017

Course Code: ME256	MANUFACTURING SCIENCE LABORATORY	Credits 0-0-3: 1.5

Pre-Requisites: NIL

Course Outcomes:

CO1	Test the properties of moulding sands.
CO2	Fabricate weldments using gas and arc welding.
CO3	Evaluate the quality of welded joints and cast components using non-destructive testing methods.
CO4	Study the metallurgical changes in welded joints.
CO5	Perform formability studies on sheet metals.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

List of Experiments:

Casting

1. Demonstration on sweep pattern and core making in mould preparation
2. Calculate the amount of the clay content in the given moulding sand
3. Find the grain fineness number of the given moulding sand
4. Find the green and dry shear strength, compression strength and permeability of the given moulding sand.
5. Find shatter index of the given moulding sand

Welding

6. Fabricate the butt joint in the given samples by using shielded metal arc welding in the given samples
7. Fabricate butt joint in the given samples by using gas welding, SAW, TIG and MIG welding.
8. Join metal plates in the given samples using resistance spot welding
9. Join rectangular cross section plates in the given samples by flash butt welding
10. Identify welding defects by liquid penetration test in the welded sample
11. Microstructural evolution of weldments

Forming

12. Component developments using sheet metal
13. Experiments in rolling
14. Forming of deep drawing components

Learning Resources:

Text Books:

1. Manufacturing Science, Amitabha Ghosh and A. K. Mallick, Affiliated East-West Press Pvt. Ltd. 2010.

2. Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, M. P. Groover, Wiley India Private Limited, 3rd edition, 2009.

Reference Books:

1. Principles of Foundry Technology, P.L. Jain, TMH, 2014
2. Manufacturing Technology Foundry, Forming and Welding, P.N. Rao, TMH, 2nd Edition, 2017

Course Code: ME257	COMPUTER AIDED MACHINE DRAWING	Credits 0-0-3: 1.5

Prerequisites: NIL

Course Outcomes:

CO1	Understand the representation of materials used in machine drawing.
CO2	Draw the machine elements including keys, couplings, cotters, riveted, bolted and welded joints.
CO3	Construct an assembly drawing using part drawings of machine components and make cost estimates.
CO4	Represent tolerances and the levels of surface finish of machine elements.

Course Articulation Matrix:

	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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

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, Rivetted joints, Shaft Couplings, Bearings and Pipe joints.
Assembly Drawing Practice: Draw the assembly drawings of Swivel bearing, Machine Swivel vice, Tool head of shaper, Tailstock, Stop valve, Blow-off cock, Screw Jack, Centrifugal pump Stuffing Box, Pedestal Bearing using the component drawings.
Part drawing from assembly drawing: Foot step bearing, Eccentric, connecting rod, square tool post, Drill jig, Feed check valve. Cost estimation for designed and machined components. Estimation of manufacturing cost.
Machine Drawing practice using AutoCAD.

Learning Resources:

Text Books:

1. Machine Drawing, Bhatt, N.D., Charotar Publishing House, 50th Edition 2016.
2. Machine Drawing, Sidheswar, N., Kannaiah, P. and Sastry, V.V.S., Tata McGraw Hill Book Company, New Delhi, 2000.
3. Production Drawing, Kannaiah, P., New Age International, 2009

III Year, I Semester

Course Code: ME301	GEOMETRIC MODELLING FOR CAD	Credits 3-0-0: 3

Pre-requisites: NIL

Course Outcomes:

CO1	Apply geometric transformations and projection methods in CAD.
CO2	Develop geometric models to represent curves.
CO3	Design surface and solid models for engineering design.
CO4	Apply mesh generation method for engineering analysis.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Detailed syllabus:

Introduction: Introduction to CAE, CAD. Role of CAD in Mechanical Engineering, Design process, Requirements of Modelling, Geometric modelling, Software tools for CAD, Input and Output Devices for CAD System.

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.

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. Surface's 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**.**

Introduction to Engineering Analysis: Finite Element Analysis, Criteria of Mesh Quality, Mesh Generation Methods (Mapped Mesh Generation, Triangulation etc.).

Text Books:

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

Reference Books:

1. Principles of CAD/CAM/CAE, Kunwoo Lee, Pearson, 1999.

Online Resources:

- NPTEL Lecture Series: https://nptel.ac.in/courses/112/102/112102101/, https://nptel.ac.in/courses/112/104/112104031/
- MIT OCW: https://ocw.mit.edu/courses/mechanical-engineering/2-158j-computational-geometry-spring-2003/

Course Code: ME302	MACHINE TOOLS AND METROLOGY	Credits 3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Analyze the kinematic motions in a machine tool.
CO2	Estimate machining times for the machining operations
CO3	Design speed and feed gear boxes for a given configuration.
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:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Machine Tools:

Introduction: Generatrix and Directrix, Elements of M/C Tools, M/C Tool drives, Classification of Machine Tools

Lathe: Types, Parts, Feed Mechanisms, Specifications of lathe, Lathe Operations, Accessories and Attachments, Machining time estimation

Shaper and Planer: Types, Specifications, Crank and slotted link mechanism, Stroke length and position adjustments, Automatic feed mechanisms, Shaper Vs Planer, Machining time estimation

Drilling: Operations, Types, Mechanisms, Nomenclature of a drill, Machining time estimation

Milling: Types, Up Milling Vs Down Milling, Types of milling cutters, Operations, Machining time estimation, Methods of indexing, dividing head

Grinding: Specification and selection of grinding wheels, Truing, Dressing, Classification of Grinding wheels

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

Regulation of Speed and Feed Rates: Introduction, Methods of Speed and Feed Regulation, Ray Diagrams and Design Considerations, Design of Speed Gear Boxes, Feed Drives.

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.

Interferometry: Principle of Interference, Optical Flat, Fringe Patterns, NPL Interferometer.

Geometric Form Measurement: Straightness, Flatness, Roundness, Coordinate Measuring Machine.

Text Books:

1. Manufacturing, Engineering & Technology. Kalpakjian, S. and Steven R. Schmid, Pearson Education, 2013
2. Manufacturing Technology–Metal Cutting and Machine Tools, P.N. Rao, Tata McGraw Hill, New Delhi, 2000.
3. Machine Tool Design, N.K. Mehta, Tata McGraw Hill, 2012
4. Engineering Metrology, I.C. Gupta, Dhanpat Rai & Sons,2003
5. Engineering Metrology, R. K. Jain, Khanna Publishers, 19/e, 2005.

Reference Books:

1. Geometric Dimensioning and Tolerancing, D. James, and S, Meadow, Marcel Dekker Inc.,1995.
2. Elements of Workshop Technology, Vol. II, S.K. Hajra Chowdary, and A.K. Hajra Chowdary, Asia Publishing House, Bombay, 2003.

Online resources

1. https://nptel.ac.in/courses/112/105/112105127/
2. https://nptel.ac.in/courses/112/106/112106179

Course Code: ME303	MECHANICAL MEASUREMENTS	Credits 3-0-2: 4

Pre-Requisites: NIL

Course Outcomes:

CO1	Understand the measurement terminologies and the concept of generalized measurement system.
CO2	Estimate errors and uncertainty in measurements using statistical analysis.
CO3	Analyze the zeroth, first and second order measurement systems.
CO4	Select sensors for measurement of specific parameters with required accuracy.
CO5	Calibrate measuring instruments with given standards.
CO6	Design experiments by combining measuring devices to obtain desired outputs.

Course Articulation Matrix:

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

Syllabus:

Basics of Measurements: Introduction, Generalized measurement system, Signal flow diagram of measurement system, Inputs and their methods of correction, Dynamic response – zeroth, first and second order measuring systems.

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.

Nuclear, thermal radiation measurement: Measurement of reflectivity, transmissivity, emissivity, nuclear radiation, neutron detection, etc.

Other measurements: Basics in measurement of torque, force, strain

Advanced topics: Issues in measuring thermos-physical properties of micro and Nano

fluidics

Design of Experiments: Basic ideas of designing experiments, Experimental design protocols with some examples.

List of Experiments for Lab:

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 micro meter.
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.

Textbooks:

1. Mechanical Measurements, Thomas G Beckwith, Pearson publications, 2006, 6th Edition
2. Measurement systems, Ernest O Doebelin, Tata McGraw Hill publications, 2019, 7th Edition
3. Experimental Methods for Engineers, J P Holman, Tata McGraw Hill publications, 2011, 7th Edition

Reference Books:

1. An Introduction to Error Analysis, John R. Taylor, University Science Books, 1997, 2nd Edition
2. Mechanical Measurements, S P Venkateshan, Ane Books Pvt. Ltd., 2015, 2nd Edition.

Online Resources:

1. Mechanical Measurements and Metrology by Prof. S P Venkateshan (IIT Madras), NPTEL Course (Link: https://nptel.ac.in/courses/112/106/112106138/).
2. Principles of Mechanical Measurement by Prof. Dipankar N Basu (IIT Guwahati), NPTEL Course (Link: https://nptel.ac.in/courses/112/103/112103261/).

Course Code: ME304	DESIGN OF TRANSMISSION ELEMENTS	Credits 3-0-0: 3

Pre-requisites: NIL

Course Outcomes:

CO1	Design the required size of shaft, key and coupling for the given application.
CO2	Design an appropriate gear for the given operating conditions.
CO3	Design a suitable bearing for the given application.
CO4	Design the flexible elements for transmitting the given power.
CO5	Design clutches, brakes and I.C. engine parts.

Course Articulation Matrix:

	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, Oldham's 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 Petroff'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 clutch, 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 (Self-study/Assignment): Design of engine parts such as Piston, Connecting rod and Crank shaft.

Text Books

1. Mechanical Engineering Design. Richard G. Budynas, J Keith Nisbett, Shigley's. McGraw Hill, 2011, 9th edition
2. Design of Machine Elements, V B Bhandari, Tata McGraw Hill Education Private Limited, 2012, 3rd Edition

Reference Books

1. Machine design an integrated approach, Robert L Norton, Pearson Education, Second edition, 2009.
2. Machine Design, Black and Adams, McGraw Hill and Co, New Delhi, 2002.

Course Code: ME305	MANAGEMENT SCIENCE AND PRODUCTIVITY	Credits 3-0-0: 3

Pre-requisites: NIL

Course Outcomes:

CO1	Understand the role of production systems to support a given competitive strategy
CO2	Understand the role of productivity in streamlining a production system.
CO3	Apply the inventory management tools in managing inventory.
CO4	Apply quality engineering tools in designing products and process controls.
CO5	Apply PERT and CPM in the management of projects.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PS02
CO1	2	2	2	2		2		2	2		2	2	3	3
CO2	2	2											2	2
CO3	2	3	2	3				2	2			2	3	3
CO4	2	3	2	3				2	2				3	3
CO5	2		2				2	2	2	2	3		2	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Production Systems: Evolution of production systems, Classification and characterization, Competitive strategies, Production and Inventory control 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, Predetermined Time Standards.

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

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

Project Management: Project activities, Network diagrams, CPM, PERT, Project Feasibility studies.

Text Books:

1. Operations and Supply Chain Management, Chase, Tata McGraw Hill, 2017, 14th Ed.
2. Operations Management: Strategy and Analysis, Krajewski L.J. and Ritzmen L.P, Pearson Education, 2010, 9th Ed.
3. Operations Management: Theory and Practice, Mahadevan. B, Pearson Education, 2015, 3rd Ed.

Reference Books:

1. Factory Physics: Foundations of Manufacturing Management, Hopp W. J. and Spearman M. L., McGraw Hill International Edition, 2008, 3rd Edition.

Online Resources:

1. MIT open courseware.
2. NPTEL Lectures
3. Swayam

Course Code: ME306	THERMAL MACHINES	Credits 3-0-0: 3

Pre-requisites: NIL

Course Outcomes:

CO1	Analyze the performance of thermal machines using thermodynamic concepts.
CO2	Analyze power plant cycles.
CO3	Analyze the performance of impulse and reaction turbines.
CO4	Design gas turbine and steam turbine components.
CO5	Evaluate the performance of thermal machines.

Course Articulation Matrix:

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

Syllabus:

Review of Basics: First law, Second law, Carnot cycle, Fundamentals of Rotating Machines – Energy Equation, Degree of Reaction.

Rankine Cycle: Properties of Pure Substances, Rankine Cycle, Steam Power plant Layout.

Boilers: Classification, Components, Draught, Chimney height calculations.

Steam Turbines: Steam Nozzles, Area- velocity relationship, Performance characteristics of Nozzles, Impulse and reaction Turbines, Governing of Steam Turbines.

Condensers: Types of Condensers -Jet, Surface and Evaporative Condensers.

Reciprocating Compressors: Construction, P-V diagram, Clearance volume, Multi-stage compressors, Efficiency.

Gas Turbine Cycles: Analysis of ideal and practical Gas Turbine Cycles for shaft power and propulsion.

Centrifugal Compressors: Construction, Principle of Operation, T-s diagram, Energy equation, velocity triangles, Performance Characteristics.

Axial Flow Compressors: Construction, Principle of Operation, T-s diagram, Energy equation, velocity triangles, Degree of reaction, Performance characteristics.

Combustion Chambers: Gas turbine combustion systems, Geometry, Factors affecting Design & Performance.

Textbooks:

1. Gas Turbines, V. Ganesan, Tata McGraw Hill Book Company, 2017, 3rd Edition,
2. Power Plant Engineering, P.K. Nag, McGraw Hill Education, 2017, 4th Edition,
3. Power Plant Engineering, A. V. Domukundwar, S.C. Arora and S. Domukundwar, Dhanpat Rai & Co., 2016, 6th Edition
4. F.S., Thermal Engineering, Mathur, M.L., Mehta, Jain Publishers, 2009.

Reference Books:

1. Gas Turbine Theory, H. Cohen , G.F.C. Rogers , H.I.H. Saravanamuttoo, Paul Straznicky, and Andrew Nix, 7th Edition, Pearson Education, 2019.
2. Compressors and Fans, Yahya, S.M., Turbines, 4th Edition, McGraw Hill Education, 2017.

Online Resources:

1. https://nptel.ac.in/courses/112/106/112106303/
2. https://nptel.ac.in/courses/112/106/112106133/
3. https://nptel.ac.in/noc/courses/noc21/SEM2/noc21-me86/
4. https://www.digimat.in/nptel/courses/video/112107291/L01.html

Course Code: ME307	THERMAL ENGINEERING LABORATORY	Credits 0-0-3: 1.5

Pre-requisites: NIL

Course Outcomes:

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

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PS02
CO1	3	3		3	2				3	2			2	2
CO2	2	1		3	2	2			3	2			2	2
CO3	3	3		1	2		2		3	1			2	2
CO4	3	3		3	3	2	2		3	2			2	2
CO5			2	2	3				3	2	3	3	2	2

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. Demonstration of boiler

Text Books:

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

Department Elective -I

Course Code: ME311	MECHANICAL VIBRATIONS	Credits 3-0-0: 3

Pre-requisites: NIL

Course Outcomes:

CO1	Develop schematic models for physical systems and formulate governing equations of motion.
CO2	Analyze the vibration characteristics including critical speed of rotating and reciprocating systems
CO3	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:

	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
CO5	3	3	3	1	1							2	2	2
CO6	3	3	2	2	2							2	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.

Text Books:

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

Course Code: ME312	OPTIMIZATION FOR ENGINEERING DESIGN	Credits 3-0-0: 3

Pre-requisites: NIL

Course Outcomes:

CO1	Formulate a design task as an optimization problem
CO2	Solve unconstrained and constrained optimization problems
CO3	Solve the nonlinear optimization problems with evolutionary methods.
CO4	Apply data-driven techniques for solving optimization problems.

Course Articulation Matrix:

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

Detailed syllabus:

Introduction to optimization in design: Introduction to Engineering Design, Identification of Customer Requirements, Mapping Customer Requirements to Engineering Characteristics, 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.

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.

Data-driven Techniques in Optimization: Machine Learning Methods (Decision Tree, KNN algorithm, Gradient boosting algorithm etc.).

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

Text Books:

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.

Reference Books:

1. Gilbert Strang, Linear Algebra and Learning from Data, Wellesley-Cambridge Press, 2019.

Online Resources:

1. nptel Lecture Series: https://nptel.ac.in/courses/112/105/112105235/,
2. https://nptel.ac.in/courses/112/101/112101298/ ,
3. https://nptel.ac.in/courses/112/106/112106064/
4. Stanford Lecture Series: https://web.stanford.edu/class/ee364a/

Course Code: ME313	COMPUTATIONAL FLUID DYNAMICS	Credits 3-0-0: 3

Pre-requisites: NIL

Course Outcomes:

CO1	Explain the differential equations for flow phenomena and numerical methods for their solution.
CO2	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	Determine forces in both internal and external flows.

Course Articulation Matrix:

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

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.

Text Books:

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

Reference Books:

1. Computational Fluid Dynamics, Chung, T.J., Cambridge University Press, 2003.
2. Computational Fluid Mechanics and Heat Transfer, Anderson, D.A., Tannehill, J.C., and Pletcher, R.H., McGraw Hill Book Company, 2002

Course Code: ME314	ALTERNATE FUELS	Credits 3-0-0: 3

Prerequisites: NIL

Course Outcomes:

CO1	Categorize, interpret and understand the essential properties of fuels for IC engines
CO2	Identify the need for alternate fuels and characterize prospective alternate fuels
CO3	Evaluate the storage and dispensing facility requirements
CO4	Analyze the implement limitations with regard to performance, emission and materials compatibility
CO5	Develop strategies for control of emissions as per the legislation standards

Course Articulation Matrix:

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

Syllabus:

Reactive Systems: Introduction, Need for alternate fuels, Desirable characteristics of good alternate fuel, Properties of air, Combustion with air, Equivalence ratio, Enthalpy of formation, Adiabatic combustion temperature, Dissociation

Introduction: Estimation of petroleum reserve – Need for alternate fuels – Availability and properties of alternate fuels, ASTM standards

Alcohols: General Use of Alcohols – Properties as Engine fuel – Gasoline and alcohol blends – Performance in SI Engine – Methanol and Gasoline blend – Combustion Characteristics in engine – emission characteristics

Vegetable oils: Soya been Oil, Jatropha, Pongamia, Rice bran, Mahua etc 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 cells

Automobile emissions & its control: Evaluating vehicle emissions – EURO standards – Indian standards

TEXTBOOKS:

1. Alternate Fuels Guide Book, L. Richard, P.E. Bechhold, Society of Automotive Engineers, 1997

2. Hydrogen fuel for surface transportation, Norbeck, M. Joseph, Society of Automotive Engineers, 1996
3. Air Pollution and its Control, S.C. Bhatia, Atlantic Publications, 2007

REFERENCE BOOKS:

1. Global Warming in an unequal world, Anil Agarwal, Sunita Narain;; Centre for Science and Environment, New Delhi, 2003
2. Handbook of Alternate Fuels Technology, Sunggyu Lee, James G. Speight, Sudarshan K. Loyalka; CRC Press, 2007

Course Code: ME315	ADVANCED WELDING TECHNOLOGY	Credits 3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Understand the weldability of metals
CO2	Apply laser beam welding for joining ferrous, non-ferrous and dissimilar material
CO3	Understand the mechanism of solid state joining processes
CO4	Classify different hybrid welding process
CO5	Understand the allied welding process for joining of metals and plastics

Course Articulation Matrix:

	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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Weldability of Metals: Weldability of Plain Carbon Steels, stainless steel problems in welding of stainless steel and their remedy, and aluminium alloys solidification cracking, hydrogen induced porosity, partial melting zone and liquation cracking, HAZ softening, precautions in the welding of age hardenable alloy. Challenges associated with welding of dissimilar alloy system

Heat Flow in Welding: Calculation of peak temperature; width of Heat Affected Zone; cooling rate and solidification rates; weld thermal cycles

Laser Beam welding (LBW): Welding Efficiency; Mechanism of Laser Welding: Conduction Mode Welding, Keyhole Welding; Laser Welding Parameters: Joint Configuration; Material Considerations; ferrous, Nonferrous alloys, Ceramics, Polymers, Dissimilar Materials; Weldment Discontinuities: Porosity, Humping, Spiking; Advantages and Disadvantages of Laser Welding; Special Techniques; Heat Treatment; Specific Applications.

Friction stir welding and processing: Classification of solid-state welding processes, Review of Friction stir welding, Selection of tool design, Fixture design, modification of tool and features, stir welding, submerged friction stir welding. Friction stir processing, Process variables, Surface modification by friction stir processing, Production of composite by friction stir processing.

Ultrasonic welding: Ultrasonic welding system and process variation, mechanism and working, process parameters, weldability of metal, dissimilar alloys, plastics and metal-plastics. advantages and limitations applications.

Magnetic Pulse Welding: Introduction, process parameters, interface structure and joint

formation mechanism, dissimilar material welding using magnetic pulse welding

Hybrid welding processes: GTAW and laser welding, GMAW and Laser welding, Underwater welding, Vibration assisted welding, process, advantages and Limitations, A-TIG welding, Cold Metal Transfer welding process, advantages, limitations and applications.

Allied Welding Process: Soldering, Brazing Adhesive bonding, vacuum brazing, diffusion bonding, Induction welding of plastics, process description, application, advantages and limitations.

Text Books:

1. Welding Engineering and Technology, R. S. Parmar, Khanna Publishers, 2014
2. Modern Welding Technology, S.V. Nadkarni, Oxford IBH Publishers, 2015.
3. Joining of Materials and Structures, W. Messler Robert Jr., Elsevier Butterworth–Heinemann, 2004

Reference Books:

1. ASM Handbook: Welding Fundamentals and Processes, L. Li, Volume 6A.
2. Welding handbook, volume 4-material and application. A. O'Brien, American welding society, 2011
3. The welding of aluminium and its alloys, Mather's Gene, Woodhead publishing, 2002.

Online Resources:

1. https://nptel.ac.in/courses/113/106/113106087/
2. https://nptel.ac.in/courses/112/103/112103244/
3. https://www.twi-global.com/technical-knowledge

Course Code: ME316	ADVANCED METAL CASTING	Credits 3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Apply solidification principles in designing the casting processes
CO2	Identify defects in castings.
CO3	Model components for castings using CAD tools.
CO4	Design gating system for metal casting processes

Course Articulation Matrix:

	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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Processing of Castings:

Metal Casting-Overview: Applications and production, historical perspective, casting processes - The 10 Rules for good castings.

Solidification structure - Heat transfer - Development of matrix structure – Structure and Structure Formation in Cast Materials – Segregation - Micro segregation in Alloys – Peritectic Reactions and Transformations - Macro segregation in Alloys

Defects and Properties of finished Castings – Entrainment – Solidification Shrinkage – Linear Contraction – Compact defects – Effect of defects on properties of castings.

Design of Casting Components:

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.

Text Books:

1. Metal casting: CAD and Analysis, B. Ravi, PH Publication, 2014.
2. Materials Processing during Casting, Hasse Fredriksson, Ulla Akerlind, John Wiley and Sons Ltd, 2006

Reference Books:

1. John Campbell, Complete Casting Handbook Metal Casting Processes, Techniques and Design, Elsevier, 2011.

III Year, II Semester

Course Code: ME351	REFRIGERATION AND AIR-CONDITIONING	Credits 3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Understand the principles and applications of various natural and artificial refrigeration systems.
CO2	Identify methods for performance improvement of vapor compression refrigeration systems.
CO3	Demonstrate the working principles of air, vapor absorption, steam-jet, vortex tube, thermoelectric and magnetic 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:

	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

Syllabus:

Introduction: Basic Definitions of Refrigeration and Air-Conditioning, History of Refrigeration, Natural and Artificial Refrigeration Methods, Techniques to produce low temperatures, A Brief Review on Thermodynamics, Heat Transfer and Fluid Mechanics, Applications of Refrigeration.

Air Refrigeration: Air Refrigeration Cycles - reversed Carnot cycle, Bell-Coleman cycle analysis, various methods of Aircraft Refrigeration (Simple, Bootstrap, Reduced ambient and Regenerative air cooling) systems: Analysis, Merits and demerits.

Vapor Compression Refrigeration System (VCRS): Ideal VCR cycle (Working, Analysis and Limitations), Standard VCRS (Working and Analysis), Methods to improve performance of VCRS (Sub cooling, superheating and Capillary Liquid-Suction Heat Exchanger), Multi-Stage VCRS (Flash Gas removal, Flash Inter cooling and Water inter cooling), Cascade Refrigeration.

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

Components of Refrigeration Systems: Compressors: Positive Displacement (Reciprocating and Rotary), Dynamic (Centrifugal and Axial) Compressors, Condensers and Evaporators (Both Natural and Forced Convection type), Expansion Devices and other components of the system.

Vapor Absorption systems: Vapor Absorption Refrigeration Systems (Working and

Analysis), Absorbent - Refrigerant combinations, Water-Ammonia Systems, Water-Lithium Bromide System, Contrast between the two systems, Modified Version of Aqua-Ammonia System with Rectifier and Analyzer Assembly.

Other Refrigeration systems: Brief Discussion on (i) Steam-Jet refrigeration system, (ii) Vortex tube refrigeration, (iii) Thermoelectric refrigeration system and (iv) Magnetic refrigeration

Psychrometry: Classification of Air-Conditioning Systems, ASHRAE Nomenclature, Applications of Air-Conditioning, Psychrometry - Air-water vapor mixtures, Psychrometric Properties, Psychrometric or Air-Conditioning processes, Psychrometric Chart.

Air-Conditioning Systems: Classification of Air-Conditioning Systems, Psychrometry of Air-Conditioning Systems, Thermal Comfort (Definition and Psychrometric Properties for Thermal Comfort), Mathematical Analysis of Air-Conditioning Systems, Cooling and Heating Load Estimation, a brief discussion on Ventilation.

Text Books:

1. Refrigeration and Air Conditioning, Arora Ramesh Chandra, PHI Learning Pvt. Ltd., India, 2012
2. Refrigeration and Air-Conditioning, Arora, C. P., Tata McGraw - Hill, New Delhi, 2000.

Reference Books:

1. Principles of Refrigeration, Roy J. Dossat, Wiley Limited, 1978
2. Refrigeration and Air-Conditioning, Stoecker, W. F., and Jones, J. W., McGraw - Hill, New Delhi, 1983.

Data Books:

1. Refrigerant and Psychrometric Properties - Tables and Charts [SI Units], M. L. Mathur, and F. S. Mehta, Jain Brothers, 2020 (Revised Edition).

Online Resources:

1. Refrigeration and Air-Conditioning by Prof. R.C Arora and Prof. M. Ramgopal (IIT Kharagpur), NPTEL Course (Link: https://nptel.ac.in/courses/112/105/112105128/)
2. Refrigeration and Air-Conditioning by Prof. Ravi Kumar (IIT Roorkee), NPTEL Course (Link: https://nptel.ac.in/courses/112/107/112107208

Course Code: ME352	MACHINING SCIENCE	Credits 3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Develop interrelations among ASA, ORS and NRS systems of tool geometry.
CO2	Analyze the stresses, cutting forces, temperature, power and specific energy in metal cutting with single point cutting tool.
CO3	Select cutting fluids, tool materials and coatings for improving tool life and machinability.
CO4	Estimate optimum cutting speed with respect to production cost and production rate.
CO5	Analyze the cutting forces, temperature, power and specific energy in machining with multi point cutting tool.
CO6	Select a modern machining process based on the effect of various process parameters.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: 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, 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).

Modern Machining Processes: An overview of modern machining processes – Classification, Mechanical Processes – Ultrasonic, water jet and abrasive jet machining - Working principle, application, economy and process selection, Mechanism of material removal, process parameters, Electrochemical Processes – Chemical machining, electro chemical machining - Working principle, application, economy and process selection, Mechanism of material removal, process parameters, Electric Discharge Machining (sinking EDM and Wire cut EDM) - Working principle, application, economy and process selection, Mechanism of material removal, process parameters.

Text Books:

1. Machining and Machine Tools, A. B. Chattopadhyay, Wiley, 2nd Edition, 2017
2. Fundamentals of metal cutting and machine Tools, B L Juneja and G S Sekhon, New Age International publishers, Revised 2nd Edition, 2017.

Reference Books:

1. Manufacturing Science, Amitabha Ghosh and A.K. Mallik, East-West Press, 2nd Edition, 2010
2. Modern Machining Processes, P. C. Pandey and H. S. Shan, TMH, 2017.
3. Advanced manufacturing Processes, V. K. Jain, Allied Publishers Pvt. Ltd, 2002.

Online Resources:

1. https://nptel.ac.in/courses/112/105/112105126/
2. https://nptel.ac.in/courses/112/105/112105127/

Course Code: ME353	MECHATRONICS	Credits 3-0-0: 3

Pre-requisites: NIL

Course Outcomes:

CO1	Model and analyze mechatronic systems for an engineering application
CO2	Identify sensors, transducers and actuators for monitoring and controlling the behavior of processes and products.
CO3	Develop PLC programs for an engineering application.
CO4	Evaluate the performance of mechatronic systems.

Course Articulation Matrix:

	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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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

Sensors & Actuators: Proximity Sensor, force sensors, sensors used in mechatronics systems. Electrical Actuators: Solenoids, relays, DC motor, Servo motor, BLDC Motor, AC Motor, stepper motors. Hydraulic & Pneumatic devices – Power supplies, different control valves, cylinder sequencing. Design of Hydraulic & Pneumatic circuits. Piezoelectric actuators, Shape memory alloys actuators.

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, Time Domain Analysis, Stability analysis using Routh-Hurwitz criteria .

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 & Principles: Introduction, AI, Cyber physical System, Cloud computing, machine learning

Text Books:

1. Mechatronics, W. Bolton, Addison Wesley Longman Ltd, 2010, 5th Edition
2. Mechatronics System Design, Devdas Shetty & Richard Kolk, PWS Publishing, 2009, 3rd Edition

Reference Books :

1. Introduction to Mechatronics and Measurement systems, Alciatore David G and Histand Michael B, Tata McGraw Hill, 2012, 4th Edition.
2. Mechatronics : A foundation course, Clarence W. de Silva, CRC Press, 2010.

Online references:

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

Course Code: ME354	OPERATIONS PLANNING AND CONTROL	Credits 3-0-0: 3

Pre-requisites: NIL

Course Outcomes:

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:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PS02
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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: Milestones in the evolution of production systems, Overview of Production Planning and Control Hierarchy; Review of EOQ and Inventory control systems.

Material Requirements Planning: Concept of Dependent Demand; Structure of MRP system, MRP Calculations, Planning Issues, Implementation Issues.

Just in Time Production Systems: Evolution, Characteristics of JIT Systems: Small lot production, Stable MPS, Kanban System, Continuous Improvement, TPM, Strategic Implications of JIT System.

Factory Physics: Basic factory dynamics, Variability basics, Push and pull production systems, CONWIP.

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, Causal methods, Time-series methods.

Theory of Constraints: TOC and Drum-Buffer-Rope, TOC process as applied to Marketing, Production and Project Management.

Text Books:

1. Operations Management: Strategy and Analysis, L.J. Krajewski and L.P Ritzmen, Pearson Education, 2010, 9th Edition.
2. Operations Management for Competitive Advantage, R.B. Chase, F.R. Jacobs and N.J. Aquilano, Tata McGraw Hill Book Company, New Delhi, 2011, 11th Edition.
3. Factory Physics: Foundations of Manufacturing Management, Hopp W. J. and Spearman M. L. McGraw Hill International Edition, 2008, 3rd Edition.
4. Operations Management: Theory and Practice, Mahadevan. B., Pearson Education, 2015, 3rd Edition.

Reference Books:

1. The Goal – A process of ongoing improvement, Eliyahu M Goldratt, Gower Book, 2004 3rd Edition
2. Critical Chain, Eliyahu M Goldratt, Gower Book, 1997.

Online Resources:

2. https://www.dbrmfg.co.nz – for understanding TOC implementation.

Course Code: ME355	MECHATRONICS LABORATORY	Credits 0-0-2: 1

Pre-requisites: NIL

Course Outcomes:

CO1	Measure load, displacement and temperature using analogue and digital sensors.
CO2	Develop PLC programs for controlling of traffic lights, water level, lifts and conveyor belts.
CO3	Develop Arduino & C++ 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:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PS02
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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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
    5.
2. **Mobile Robot with P89V51RD2microcontroller & Arduino**
    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
    5. Programs using Arduino boards
3. **PLCPROGRAMMING**
    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 Mat lab

2. Simulation and analysis of PID controller using SIMULINK

Reading:

1. Lab Manual
2. Mechatronics System Design, Devdas Shetty, Richard Kolk, PWS Publishing, 2009, 3rd Edition.
3. Introduction to Mechatronics and Measurement systems, Alciatore David G, Histand Michael B, Tata McGraw Hill, 2012, 4th Edition

Course Code: ME356	CFD LABORATORY	Credits 0-1-2: 2

Prerequisites: NIL

Course Outcomes:

CO1	Formulate problems in fluid flow and heat transfer
CO2	Analyze the influence of non-dimensional parameters in solving the governing equations.
CO3	Solve real life thermal engineering problems using software packages.
CO4	Model and analyze thermal engineering equipment using CFD

Course Articulation Matrix:

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

Syllabus:

1. Heat conduction through a slab
2. Lumped heat capacity model
3. Laminar pipe Flow
4. Lid driven Cavity
5. Natural convection in a cavity (steady state)
6. Natural convection in a cavity (Unsteady)
7. Turbulent Pipe Flow
8. Flow over cylinder
9. Heat transfer in porous media
10. Conjugate heat transfer problem

Text Books:

1. Computational Fluid Dynamics, J.D Anderson (Jr), McGraw-Hill Book Company, 2017.
2. Computational Fluid Dynamics, K.A. Hoffman, and S.T. Chiang, Vol. I, II and III, Engineering Education System, Kansas, USA, 2000.

Reference Books:

1. Computational Fluid Dynamics, T.J. Chung, , 2nd Edition, Cambridge University Press, 2014.
2. Computational Fluid Mechanics and Heat Transfer, D.A. Anderson, J.C. Tannehill and R.H. Pletcher, 3rd Edition, CRC Press, 2013.
3. An Introduction to Computational Fluid Dynamics, H.K. Versteeg, and W. Malalasekara, Pearson Education, 2010.
4. User manuals of the software.

Course Code: ME357	MACHINING AND METROLOGY LABORATORY	Credits 0-0-3: 1.5

Pre-Requisites: NIL

Course Outcomes:

CO1	Perform machining 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:

	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	

1 - Slightly; 2 - Moderately; 3 – Substantially

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 Gear drives).
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 auto-collimator.
4. Measurement of Thread and Gear profiles for their form and geometrical accuracies.
5. Demonstration Coordinate Measuring Machine for the evaluation of form errors.

Text Books:

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

Department Elective -II

Course Code: ME361	FINITE ELEMENT METHOD	Credits 3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Model the solid mechanics and Heat transfer problems for applying finite element method.
CO2	Solve problems in one dimensional structures including trusses, beams and frames.
CO3	Formulate FE characteristic equations for two dimensional elements for evaluating plain stress, plain strain, and axi-symmetric and plate bending problems.
CO4	Solve the finite element formulations using MATLAB.

Course Articulation Matrix:

	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

Syllabus:

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

Fundamental concepts: Calculus of variation and solving differential equations, Ritz method, Galerkin method, 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, penalty method, computer implementation and case studies.

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

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, element matrices and case studies.

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

Three Dimensional Problems: Finite element formulation for 3-D problems, mesh

preparation, hexahedral elements, shell elements and case studies.

Textbook

1. Textbook of Finite Element Analysis, P. Seshu, PHI, 2009.
2. Finite Element Methods for Engineers, U.S. Dixit, Cengage Learning, New Delhi and Singapore, 2009.
3. Finite Element Method in Engineering, J.N. Reddy, Tata McGraw Hill, 2007.

References:

1. The finite element method in engineering, Rao, S. Singiresu, Butterworth-heinemann, 2017.
2. Concepts and applications of finite element analysis, Cook, D. Robert, John wiley & sons, 2007.
3. Finite element procedures, Bathe, Klaus-Jürgen, Klaus-Jurgen Bathe, 2006.
4. The finite element method: linear static and dynamic finite element analysis, Hughes, Thomas JR. Courier Corporation, 2012.
5. The Finite Element Method for Solid and Structural Mechanics, Zeincowicz, Elsevier, 2007, 4th Edition,.

Course Code: ME362	THEORY OF ELASTICITY	Credits 3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Formulate the stress - strain relations in elastic body.
CO2	Develop the governing equation with the given 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:

	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	
CO3	3	3			3			2				2	2	2
CO4		3		`2	3			2				2	2	3

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.

Polar and Cartesian Coordinate Systems: Stress, Strain and Displacement Transformations, Solution by polynomials - Saint Venant'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: State of stress and strain at a point, Principle stresses -Homogeneous deformations, Decomposition into hydrostatic and pure shear states 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.

Text Books:

1. Theory of Elasticity by Timoshenko, S.P. and Goodier, J.N. McGraw-Hill, 1970.
2. Theory of Elasticity by Sadhu Singh Khanna Publishers 2015

Reference

1. Elasticity by Barber, James R, Dordrecht: Kluwer academic publishers, 2002.
2. A Treatise on the mathematical Theory of Elasticity, A E H. Love. FB & C Limited, 2017

Course Code: ME363	AERODYNAMICS	Credits 3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Understand the principles of flight and vehicle aerodynamics.
CO2	Analyze inviscid, incompressible and irrotational flows for flow around an airfoil
CO3	Analyze compressible flow over an airfoil
CO4	Estimate the lift and drag over a vehicle body using the principles of aerodynamics

Course Articulation Matrix:

	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								2	2	1
CO3	2	3	2	3								1	2	2
CO4	3	3	3	3								1	2	2
CO5	3	2	2	2								2	2	1

Syllabus:

Introduction: Importance of Aerodynamics in flights and automobiles, Aerofoils, wings and their nomenclature, Characteristics of Airfoil, Aerodynamic Forces and Moments (Lift, drag and pitching moment coefficients), A brief review on Continuity, Momentum and Energy Equations, Application of Momentum Equation for the Estimation of Drag of a Two-dimensional Body, Substantial Derivatives, Pathlines and Streamlines of a Flow, Angular Velocity, Vorticity and Strain; Circulation; Stream Function; Velocity Potential.

Inviscid Incompressible Flows: Elementary Flows and their Superposition (Uniform flow, Source Flow, Source- Sink Flows, Doublet Flow, Non- lifting Flow over a Circular Cylinder, Vortex Flow, Lifting Flow over a Cylinder), Kutta – Joukowski Theorem and the Generation of Lift, Non-lifting flows over arbitrary bodies: Numerical Source Panel method.

Incompressible flows over airfoils: Kutta Condition, Kelvin's Circulation Theorem, Starting Vortex, Classical Thin Airfoil Theory of Symmetric and Cambered Airfoils, Lift and Moment Coefficients, Center of Pressure, Predicting Zero Lift Angle of Attack, Flapped Airfoils, Effects of Thickness.

Finite Wing Theory: The Concept of Downwash and Induced Drag – Classical Theorems: Curved Vortex Filament, Biot-Savart Law, Helmholtz's Vortex Theorems – Method of Analysis: Prandtl's Classical Lifting Line Theory, Modern Numerical Lifting Line Method, Lifting Surface Theory, Modern Vortex Lattice Numerical Method.

Compressible Flow Theory: Compressibility, Isentropic flow through nozzles, shocks and expansion waves, Rayleigh and Fanno Flow, Potential equation for compressible flow

Compressible flow past airfoils: Linearized Velocity potential, Prandtl Glauert compressibility corrections, Critical Mach number, drag divergence Mach number,

supercritical airfoils, Linearized supersonic flow, Method of characteristics, Supersonic flow over airfoils and wings, subsonic/supersonic leading edge, Hypersonic flows, real gas effects, Newtonian theory, lift and drag in hypersonic flows.

Viscous Flows: Navier- Stokes Equations, Laminar and Turbulent Flows, Boundary Layers and Boundary Layer Thickness; Displacement Thickness; Momentum Thickness and Energy Thickness; Estimation of Skin Friction Drag from Momentum Thickness over a Flat Plate; Derivation of Prandtl's Boundary Layer Equation from Navier- Stokes Equation.

Automotive Aerodynamics: Automobiles as bluff bodies, flow field around the vehicle, drag force, types of drag force, analysis of aerodynamic drag, drag coefficient of vehicles, strategies for aerodynamic development, low drag profiles, fuel consumption and performance potential of vehicle aerodynamics, effects of platooning, Case studies on modern vehicles.

Text Books:

1. Fundamentals of Aerodynamics, Anderson, J. D., McGraw-Hill Education, 2016, 6th edition.

Reference Books:

1. Aerodynamics for Engineering Students,E. L. Houghton and P. W. Carpenter, Butterworth-Heinemann, 2003, 5th edition
2. Aerodynamic of Road Vehicles: From Fluid Mechanics to Vehicle Engineering, W. H. Hucho, Butterworths Co., Ltd., 1997, 1st Edition.

Online Resources:

1. Introduction to Aerodynamics by Dr. K.P. Sinhamahapatra (IIT Kharagpur), NPTEL Course (Link: https://nptel.ac.in/courses/101/105/101105059/)
2. Experimental Gas/Aerodynamics, Prof. Job Kurian (IIT Madras), NPTEL Course (Link: https://nptel.ac.in/courses/101/106/101106040/)

Course Code: ME364	AUTOMOBILE ENGINEERING	Credits 3-0-0: 3

Pre-Requisites: Nil

Course Outcomes:

CO1	Understand the basic layout of an automobile.
CO2	Understand the operation of engine cooling, lubrication, ignition, electrical and air conditioning systems.
CO3	Analyze the vehicle transmission, suspension, steering and braking systems.
CO4	Understand automotive electronics.
CO5	Explore latest developments in automobiles.

Course Articulation Matrix:

	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							3	2	2

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 and Ignition System and Electrical system: spark Ignition engines- Fuel tank, fuel filter, fuel pump, air cleaner/filter, carburettor, 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, 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, wheel geometry.

Braking 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 axles suspension, electronic control and proactive suspension system.

Automotive air conditioning: ventilation, heating, air condition, refrigerant, compressor and evaporator.

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

Textbooks:

1. Automobile Engineering, K.M. Gupta.l, Vol.I & II, Umesh Pub, 2010.
2. Automotive Mechanics, W.H. Crouse and D.L. Anglin, Tata McGraw Hill, New Delhi,2005.
3. Automotive Mechanics, J. Heitner, Affiliated South West Press, New Delhi, 2000.

Reference:

1. Automobile Engineering, G.B. Narang, Khanna Publishers, New Delhi, 2001.
2. Automobile Engineering, Kamaraju Ramakrishna, PHI Learning pvt. Ltd., New delhi-2012.
3. Encyclopedia of Automotive Engineering, Parts 1-6, D. Crolla, D. E. Foster, T. Kobayashi and N. Vaughan (Editors-in-Chief), Wiley, 2015.
4. Automotive Engineering Fundamentals, R. Stone and J. K. Ball, SAE International, 2004.

Online resources:

1. Fundamentals of Automotive Systems - Course (nptel.ac.in)

Course Code: ME365	ADVANCED METAL FORMING	Credits 3-0-0: 3

Pre-Requisites:

Course Outcomes:

CO1	Evaluate workability of different ductile materials
CO2	Develop process maps for metal forming processes using plasticity principles.
CO3	Analyze the deformation process parameters for different engineering components.
CO4	Estimate formability limits for sheets and bulk metals.
CO5	Identify the practical applications of metal forming

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: Introduction of metal forming as a manufacturing process and its relation with other processes, Advantages of metal forming as a manufacturing process, Classifications of metal forming processes – Bulk and sheet forming, Forming equipment, Presses (mechanical, hydraulic).

Description of Material properties: Tensile test, effect of properties on forming. Sheet deformation processes: Uni-axial tension, general sheet forming processes, yielding, flow rule, work hardening hypothesis, work of plastic deformation, isotropic and anisotropic yield functions, Bauschinger effect modeling, effective stress and strain. Sheet deformation in plane stress: strain distributions, strain diagram, deformation modes, effective stress-strain laws, principal tensions.

Bulk Forming Processes: Load estimation - Rolling - Forging; open-die forging, closed-die forging, Rod, wire and tube drawing, extrusion, problems.

Sheet Forming Processes: Deep drawing, Blanking, piercing, stretch forming, formability tests, forming limit diagrams, strain path diagrams, process simulation for deep drawing.

Recent advances: Hydroforming, tailor welded blanks, friction stir welding of sheets, incremental sheet forming.

Case studies: Case studies on the manufacturing aspects of products using the lessons learnt.

Text Books:

1. Sheet metal forming processes Constitutive modeling and numerical simulation, D. Banabic, Springer-Verlag Berlin Heidelberg, 2010
2. Mechanics of sheet metal forming, Elsevier, Butterworth-Heinemann, Z. Marciniak, J. L. Duncan, S. J. Hu, 2002
3. Fundamentals of metal forming, R. H. Wagoner, J. L. Chenot, John Wiley and Sons, 1997
4. Metal forming Mechanics and Metallurgy, W. F. Hosford, R. M. Caddell, Printice Hall, 2007

Reference Books:

1. Theory of Plasticity, J. Chakrabarty, McGraw Hill, 1998.
2. Basic engineering plasticity, D. W. A. Rees, Elsevier, 2000
3. Theory of Engineering Plasticity, R. Narayanasamy, R Ponalagusamy, Ahuja Book Company, 2000.
4. Applied Metal Forming - Including FEM Analysis, Henry S. Valberg, Cambridge University Press, 2010.
5. Modeling Techniques for Metal Forming Processes, G.K. Lal, P.M. Dixit and N.Venkat Reddy, Alpha Science, 2011

Course Code: ME366	OPERATIONS RESEARCH	Credits 3-0-0: 3

Pre-requisites: NIL

Course Outcomes

CO1	Understand the concepts of operations research in 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 Mixed integer programming problems.

Course Articulation Matrix:

	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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: Historical overview of operations research, fundamentals of OR Modelling Approach.

Linear Programming: Basic assumptions, formulation, graphical method, simplex method, duality theory, 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, deterministic problems.

Integer programming: Special features, binary integer programming models, branch-and-bound technique, cutting-plane method, introduction to nonlinear programming.

Text Books:

1. Operations Research, H. A Taha, Prentice Hall of India, 2017, 10thEdition.
2. Introduction to Operations Research, F.S Hillier.and G.J Lieberman, TMH, 2009, 7th Edition.

Online Resources:

1. Optimization Methods in Management Science | Sloan School of Management | MIT OpenCourseWare

Course Code: ME367	DESIGN AND ANALYSIS OF EXPERIMENTS	Credits 3-0-0: 3

Pre-requisites: NIL

Course Outcomes:

CO1	Identify objectives and key factors in designing experiments.
CO2	Develop appropriate experimental design to conduct experiments.
CO3	Analyse 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:

	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	3	3				2		3	2	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

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.

Text Books:

1. Design and Analysis of Experiments, Montgomery D. C., John Wiley & Sons, 2010, 7thEdition.
2. Taguchi Techniques for Quality Engineering, Ross P. J., McGraw-Hill, NY, 2008.
3. Quality Engineering using Robust Design, Madhav S. Phadke, Prentice Hall, 1989

Reference Books:

1. Product and Process Design for Quality, Economy and Reliability, Dukkipati, R V and Pradip K Ray, New Age International,2010, 1st Edn.

Online Resources:

1. http://reliawiki.org/index.php/Experiment_Design_and_Analysis_Reference
2. https://ieeexplore.ieee.org/abstract/document/6771276
3. https://link.springer.com/chapter/10.1007/978-1-4684-1472-1_1

IV YEAR, I SEMESTER

Course Code: ME401	ROBOTICS	3-0-0: 3

Prerequisites: NIL

Course Outcomes:

CO1	Understand the basic components of robots and their grippers.
CO2	Model forward and inverse kinematics of robot manipulators.
CO3	Analyze forces in links and joints of a robot.
CO4	Develop a program for the robot to perform tasks in industrial applications.
CO5	Design intelligent robots using sensors.

Course Articulation Matrix:

	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

Syllabus:

Introduction: Multibody systems, Automation, Classification of robots, Anatomy, Sensors (velocity, proximity, touch, torque etc), Grippers, selection of Robot based on the Application. Demonstration of different types of Robots & tools using Robot Simulator Software like ROBODK.

Kinematics: Manipulators Kinematics, Rotation Matrix, Homogenous Transformation Matrix, Direct and Inverse Kinematics for industrial robots for Position and orientation. Demonstrate FK and IK using simulation tools.

Differential Kinematics, statics and Dynamics: Jacobian, Lagrangian Formulation, Newton- Euler Formulation for RR & RP Manipulators. Demonstrate differential kinematics using simulation tools.

Trajectory planning: Motion Control- Interaction control, Rigid Body mechanics. Demonstrate trajectory planning using simulation tools.

Control: architecture- position, path velocity and force control systems, computed torque control, Adaptive control, and Servo system for robot control.

Advanced Topics in Robotics: Motion Planning (Methods of Path planners), Robot Vision (Feature Detection & Matching, Motion Tracking, Machine Learning methods).

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.

Learning Resources:

Text Books:

1. Introduction to Robotics Mechanics and Control, Craig, J.J., Addison Wesley, 1999.
2. Introduction to robotics, Saha, Subir Kumar, Tata McGraw-Hill Education, 2014.
3. Robot modeling and control, Spong, Mark W., Seth Hutchinson, and Mathukumalli Vidyasagar. New York: Wiley, 2006.

Reference Books:

1. Modern Robotics: Mechanics, Planning, and Control, Kevin M. Lynch, Frank C. Park, Cambridge University Press, 2017.

Online Resources:

1. nptelCourses: https://nptel.ac.in/courses/107/106/107106090/ , https://nptel.ac.in/courses/112/101/112101098/, https://nptel.ac.in/courses/112/107/112107289/, https://nptel.ac.in/courses/112/104/112104298/
2. Stanford Lecture Series: https://see.stanford.edu/Course/CS223A
3. MIT OCW: https://ocw.mit.edu/courses/mechanical-engineering/2-12-introduction-to-robotics-fall-2005/

Course Code: ME402	COMPUTER AIDED MANUFACTURING	3-0-0: 3

Prerequisites: NIL

Course Outcomes:

CO1	Understand the hardware of CNC machines and additive manufacturing process
CO2	Understand the elements of automated manufacturing systems
CO3	Develop part programs with G codes and M codes for typical components
CO4	Develop part programs with APT language
CO5	Develop GT code and part families

Course Articulation Matrix:

	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	3		3	2								3	2
CO4	2	2		3	2								3	2
CO5	2	3		3	2								3	2

Syllabus:

Introduction: Automation, Types of automation, Definition of CAM

Numerical Control (NC): NC, CNC, DNC, NC positioning systems – open loop, closed loop, precision; NC modes, NC elements

CNC Hardware: 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 Machine Tools and 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.

Fundamentals of CNC Programming: 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.

Material-Handling Systems: Automatic Guided Vehicles (AGV), Industrial Robots - Anatomy & configuration, Characteristics, Grippers, Applications in manufacturing, Robot programming; Automated Storage and Retrieval Systems

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 methods of 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: 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.

Learning Resources:

Text Books:

1. CAD/CAM Principles and Applications, P.N. Rao, Tata McGraw Hill, 2010, 3rd Edition
2. 3D Printing and Additive Manufacturing: Principles & Applications, Chua Chee Kai, Leong Kah Fai, World Scientific, 2017, 5th Edition

Reference Books:

1. Automation, Production, Production Systems and Computer-Integrated Manufacturing, Mikell P. Groover, Pearson, 2018, 5th Edition
2. CAD/CAM: Computer Aided Design and Manufacturing, Grover M. P. and Zimmers E.W, Pearson Education, 2008
3. Computer Control of Manufacturing Systems, Yoram Koren, McGraw Hill Publications, 2005
4. Computer Aided Manufacturing, T.C. Chang, R.A. Wysk, H.P. Wang, Pearson Prentice Hall, 2006, 3rd Edition

Online Resources:

1. https://nptel.ac.in/courses/112/104/112104289/
4. https://nptel.ac.in/courses/112/103/112103293/
5. https://nptel.ac.in/courses/112/103/112103174/

Course Code: ME403	COMPUTER AIDED MANUFACTURING LABORATORY	0-0-2: 1

Prerequisites: NIL

Course Outcomes:

CO1	Develop manual part programs for 2D-complex profiles for Fanuc and Siemens controller using CNC Simulator and Sinutrain Software.
CO2	Generate CNC program for turning and milling of component using Master CAM and Edge CAM software.
CO3	Verify CNC code using Virtual CNC software.
CO4	Machine complex profiles on CNC machine using auto generated CNC code.
CO5	Verify STL files and print 3D parts by AM machines

Course Articulation Matrix:

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

Syllabus:

Manual Part programming for Fanuc and Siemens Controller using CNC Simulator and Sinutrain, CNC programming for turned and milled components using Edge CAM, Sinutrain and Master CAM, Training on CNC machines.

List of experiments:

1. Simulation of turn components on CNC Simulator.
2. Turning of components on spinner.com Lathe.
3. Turning of components on VDF lathe.
4. Milling simulation of 2D profiles on CNC Simulator.
5. Milling Simulation of Turbine blade on CNC Simulator.
6. Milling of 2D profiles on Max Mill CNC milling Machine.
7. Milling of 2D / 3D profiles using MasterCam.
8. Milling of 2D / 3D profiles using EdgeCam.
9. Generate and visualize CNC code using Virtual CNC Software.
10. Design and fabrication of components using 3D printer.

Learning Resources:

Text Books:

1. NITW CNC Lab Manual
2. Computer Numerical Control: Operation and Programming, John Stenerson and Kelly Curran, PHI, 2009

Reference Books:

1. Computer Aided Manufacturing, T. C. Chang, R.A. Wysk and H. P. Wang, PHI, 2009

Online Resources:

1. https://www.youtube.com/channel/UCpWCH4X4wSmvhFG950A5xug
2. http://vlabs.iitkgp.ac.in/cim/#

Course Code: ME404	COMPUTER AIDED ENGINEERING LABORATORY	0-0-2: 1

Prerequisites: NIL

Course Outcomes:

CO1	Develop MATLAB programs for solving engineering problems.
CO2	Simulate mathematical models and visualize the results.
CO3	Solve thermal, fluid and structural problems using Finite Element Analysis.
CO4	Execute mini projects for solving engineering problems.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	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	3		3				3	3		2	3	3

Syllabus:

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
5. Solve problems involving Vibrations, Optimization
6. Solve problems involving FEM, and Heat transfer
7. Introduction to Simulink

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
5. Analysing 3D Problems using Ansys
6. Harmonic analysis of a Cantilever beam
7. Mini Project

Learning Resources:

Text Books:

1. Applied Numerical Methods with MATLAB for Engineers & Scientists, Steven Chapra, McGraw-Hill, 2018, 4th Edition

Reference Books:

1. Principles of CAD/CAM/CAE, Kunwoo Lee, Pearson, 1999
2. Engineering Computation with MATLAB, David Smith, Pearson, 2013, 3rd Edition
3. Autodesk Fusion 360 Black Book, Verma G., CADACAMCAE Works, 2021, 2nd Edition

Online Resources:

1. Self-Paced Tutorials https://help.autodesk.com/view/fusion360/ENU/courses/
2. Product Documentation:https://help.autodesk.com/view/fusion360/ENU/?guid=GUID-1C665B4D-7BF7-4FDF-98B0-AA7EE12B5AC2

Department Elective – III

Course Code: ME411	NON-CONVENTIONAL ENERGY SOURCES	3-0-0: 3

Prerequisites: NIL

Course Outcomes:

CO1	Identify renewable energy sources and their utilization.
CO2	Analyze the working of solar PV and thermal systems.
CO3	Understand principles of energy conversion from alternate sources including wind, geothermal, ocean, biomass, biogas and hydrogen.
CO4	Understand the concepts of fuel cells, thermoelectric convertor and MHD generator.
CO5	Identify methods of energy storage for specific applications

Course Articulation Matrix:

	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	-
CO2	3	3	2	3	3	1	2		2			2	3	2
CO3	3	2	1	2	1	1	1		2			2	3	3
CO4	3	3	3	1	1	1	1		2			2	2	3
CO5	3	3	1	3	1	1	2		2			2	2	2

Syllabus:

Introduction: Overview of the course; Examination and Evaluation patterns; Basic concepts of energy; Introduction to Renewable Energy Technologies; Energy and Environment: Global warming, acid rains, Depletion of ozone layer; Global and Indian Scenario of renewable energy sources

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; Biomass conversion 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

Learning Resources:

Text Books:

1. Non conventional Energy Resources, B.H.Khan, Tata McGraw Hill, New Delhi, 2017, 3rd edition
2. Solar Energy-Principles of Thermal Collection and Storage, S.P.Sukhatme and J.K.Nayak, TMH, 2008, 3rd edition

Reference Books:

1. Solar Energy Thermal Processes, J.A.Duffie and W.A.Beckman, John Wiley, 2010, 2nd edition
2. Energy Technology: Non-Conventional, Renewable and Conventional, S.Rao and B.B.Parulekar, Khanna Publishers, 2010, 1st Edition

Online Resources:

1. Non-conventional Energy Resources by Prof. Prathap Haridoss (IIT Madras), NPTEL Course (Link: https://nptel.ac.in/courses/121/106/121106014/)

Course Code: ME412	AUTOMOTIVE SAFETY	3-0-0: 3

Prerequisites: NIL

Course Outcomes:

CO1	Identify different safety systems and its role in automobiles
CO2	Understand the active and passive safety systems
CO3	Describe the working principles of air-bag, ABS, seat-belt controls, comfort and convenience systems
CO4	Understand engine maintenance and its trouble shooting as well as remedial measures.
CO5	Understand maintenance of transmission, steering, braking, air conditioning and electrical systems

Course Articulation Matrix:

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

Syllabus:

INTRODUCTION

Design of the vehicle body for safety, energy equation, engine location, deceleration of vehicle inside passenger compartment, deceleration on impact with stationary and movable obstacle, concept of crumble zone, safety sandwich construction.

SAFETY CONCEPTS

Safety Concepts: Active safety, driving safety, conditional safety, perceptibility safety, operating safety, passive safety: exterior safety, interior safety, deformation behaviour of vehicle body, speed and acceleration characteristics of passenger compartment on impact.

Active Safety: Cruise control system, Lane departure warning, Safety equipment: Seat belt, regulations, automatic seat belt tightened system, Anti-locking braking system(ABS), Speed limiting device(SLD),Fire detection and suppression system(FDSS), automatic traction control, automatic vehicle stability control, Collapsible steering system, tilt able steering system, air bags, electronic system for activating air bags, bumpers design for safety.

PASSIVE SAFETY EQUIPMENTS

Seat belt, regulations, automatic seat belt tightener system, collapsible steering column, tiltable steering wheel, air bags, electronic system for activating air bags, bumper design for safety.

COLLISION WARNING AND AVOIDANCE

Collision warning system, causes of rear end collision, frontal object detection, rear vehicle object detection system, object detection system with braking system interactions.

COMFORT AND CONVENIENCE SYSTEM

Steering and mirror adjustment, central locking system, Garage door opening system, tyre pressure control system, rain sensor system, environment information system.

PREVENTIVE MAINTENANCE OF ENGINE AND TRANSMISSION LINE

Maintenance of cooling and lubricating systems, engine management service - fault diagnosis-servicing emission controls.

Clutch, transmission, axles:general checks, adjustment and service, fault diagnosis.

STEERING, BRAKE, SUSPENSION, WHEEL MAINTENANCE

Inspection, Maintenance and Service of Hydraulic brake, Drum brake, Disc brake, Parking brake. Bleeding of brakes. Inspection, Wheel alignment and balance, removing and fitting of tyres, tyre wear and tyre rotation. Inspection, Maintenance and Service of steering linkage.

Learning Resources:

Text Books:

1. Automotive Handbook, Bosch, SAE publication, 2011, 8th Edition
2. Automotive Mechanics, Srinivasan S, Tata McGraw- Hill, Publisher, 2015, 2nd Edition
3. An Introduction to Modern Vehicle Design, Jullian Happian-Smith, SAE, 2002
4. Crashworthiness of Vehicles, Johnson W, and Mamalis A G, MEP – London, 1995
5. Vehicle Service Manuals of reputed manufacturers

Course Code: ME413	CRYOGENICS	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

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:

	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

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, Polyurethane Foams (PUFs) and Polystyrene Foams (PSFs), Vacuum Insulation, and so on.

Applications: Broad Applications of Cryogenic Refrigerants in various engineering systems.

Learning Resources:

Text Books:

1. Fundamentals of Cryogenic Engineering, Mamata Mukhopadhyay, PHI, 2010
2. Cryogenic Engineering, Thomas Flynn, CRC, 2004

Reference Books:

1. Cryogenic Technology and Applications, A. R. Jha, Butterworth-Heinemann, 2005
2. Cryogenic Engineering - Fifty Years of Progress, Timmerhaus et. al., Springer, 2007

Course Code: ME414	TOOL DESIGN	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Design Locating and Clamping systems for the given component based on geometrical and dimensional features.
CO2	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.
CO5	Design Locating and Clamping systems for the given component based on geometrical and dimensional features.

Course Articulation Matrix:

	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
CO5	3	2				2							3	2

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 and classifications, 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.

Learning Resources:

Text Books:

1. Fundamentals of Tool Design, F. W. Wilson, ASME, PHI, 2010

2. Tool Design, Donaldson C, G. H. Lecain and V. C. Goold, TMH, 2010

Reference Books:

1. Jigs and Fixtures Design Manual, Prakash Joshi, McGraw-Hill, 2002, 2nd Edition
2. Design of Jigs, Fixtures and Press Tools, K. Venkataraman, Wiley Athena Academic, 2015, 1st Edition

Course Code: ME415	TOTAL QUALITY MANAGEMENT	3-0-0: 3

Prerequisites: NIL

Course Outcomes:

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:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PS02
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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: Dimensions of Quality, Quality Planning, Quality Costs and Analysis, Axioms of TQM.

Contribution of Quality Gurus: Shewhart SPC**,** Deming Philosophy, Juran Trilogy, Crosby zero Defect 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, Performance Measures, Case studies.

TQM Tools: Benchmarking, Quality Function Deployment (QFD) - House of Quality, Taguchi Robust Design Concept, Total Productive Maintenance (TPM), 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

Text Books:

1. Total Quality Management, Dale H.Besterfiled, Pearson Education, Delhi, 2006.
2. Total Quality Management, Subburaj Ramasamy, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2005.
3. Quality Management - Concepts and Tasks, Narayana V and Sreenivasan N.S., New Age International, Delhi, 1996.

Reference Books:

1. Out of the Crisis, Edward Deming, MIT Press, July, 2000

2. ISO 9000: Concepts, Methods and Implementation, Tapan P Bagchi, A.H.Wheeler, 1999

Online Resources:

1. https://deming.org/explore/seven-deadly-diseases/ - Video by Edward Deming
2. https://www.iso.org/standard/45481.html - For ISO 9000 standards

Course Code: ME416	THEORY OF PLASTICITY	3-0-0: 3

Prerequisites: NIL

Course Outcomes:

CO1	Differentiate elastic and plastic behavior from stress-strain curves.
CO2	Identify plastic yield criteria to establish constitutive modelling.
CO3	Interpret material constants in mathematical formulation of constitutive relationship.
CO4	Analyze boundary value problems with elasto-plastic properties.

Course Articulation Matrix:

	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

1 - Slightly; 2 - Moderately; 3 – Substantially

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) I

Introduction to dynamic plasticity - One-dimensional - Phase transformation and plasticity, strain gradient plasticity, dislocation plasticity, crystal plasticity.

Text Books:

1. Plasticity Theory, J. Lubliner, Dover Publishing, 2008.
2. Fundamentals of the theory of plasticity, L. M. Kachanov, Dover Publishing, 1990.
3. Nonlinear Solid Mechanics, D. Bigoni, Cambridge University Press, 2012.

Reference Books:

1. Plasticity: Fundamentals and applications, P. M. Dixit and U. S. Dixit, CRC Press, 2014.
2. Theory of Plasticity, J. Chakrabarty, 3rd Edition, Butterworth-Heinemann, 2006.
3. Theory of Engineering Plasticity, R Narayanasamy and R Ponalagusamy, Ahuja Book Company, 2000

Online Resources: Nil

Course Code: ME417	THEORY OF CONSTRAINTS	3-0-0: 3

Prerequisites: NIL

Course Outcomes:

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:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PS02
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			

1 - Slightly; 2 - Moderately; 3 – Substantially

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, Prerequisite tree, transition tree.

Text Books:

1. Goldratt's Theory of Constraints: A Systems Approach to Continuous Improvement, Dettmer H. W., ASQ Quality Press, Wiscousin, 1997
2. Critical Chain Project Management, Leach L.P., 2nd Edition, Artech House Inc, London, 2005

Course Code: ME418	CONDITION MONITORING	3-0-0: 3

Prerequisites: NIL

Course Outcomes:

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 technologies for effective plant maintenance.

Course Articulation Matrix:

	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

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

Learning Resources:

Text Books:

1. Vibration Condition Monitoring, Rao J. S., Narosa Publishing House, 2/e 2000.
2. Fault Diagnosis Application, Isermann R., Springer-Verlag Berlin, 2011.
3. Mechanical Faults Diagnosis, Collacott, R. A., Chapman and Hall, London, 1990

Reference Books:

1. Choudary K K., Instrumentation, Measurement and Analysis, Tata McGraw Hill, 2012
2. Allan Davis, Hand book of Condition Monitoring, Chapman and Hall, 2000

Course Code: ME419	TRIBOLOGY	3-0-0: 3

Prerequisites: NIL

Course Outcomes:

CO1	Understand the fundamentals of tribology and associated parameters.
CO2	Apply concepts of tribology for the performance analysis and design of components experiencing relative motion.
CO3	Analyze the surface properties for predicting their tribological properties.
CO4	Identify the lubrication regime for the given mechanical application.

Course Articulation Matrix:

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

Syllabus:

Introduction to tribology: Historical background, practical importance, and subsequent use in the field. Lubricants: Types and specific field of applications. Properties of lubricants,viscosity, its measurement, effect of temperature and pressure on viscosity, lubrication types, standard grades of lubricants, and selection of lubricants.

Friction and wear: Origin of sliding friction, Causes of Friction, friction theories, measurement methods, friction of metals and non-metals. the interfaces between two or more bodies in relative motion. Classification and mechanisms of wear, delamination theory, debris analysis, testing methods and standards. friction and wear mechanisms for metals, polymers, and ceramics, including abrasive wear, delamination theory, tool wear, erosive wear, wear of polymers and composites; Related case studies.

Surface engineering: Concept and scope of surface engineering. Surface modification – transformation hardening, surface melting, thermo chemical processes. Surface Coating – plating,fusionprocesses, vapor phase processes. Selection of coating for wear and corrosion resistance.

Lubrication: Types of lubricants, Objectives and selection of lubricant, Physical properties of lubricants, Regimes of lubrication - hydrodynamic, Elasto-hydrodynamic, mixed and boundary lubrication, Reynolds' equation, Hydrodynamic lubrication of roughened surfaces

Learning Resources:

Text Books:

1. Stachowaik, G.W., Batchelor, A.W., Engineering Tribology, Elsevier, 2010, 3rd Ed.
2. Stolarski TA, Tribology in Machine Design, Butterworth Heinemann, 2000
3. Introduction to Tribology, B. Bhushan, John Wiley & Sons, Inc., New York, 2002
4. Andras Z. Szeri, Fluid film lubrication theory and design, Cambridge University press, 1998

Department Elective-IV

Course Code: ME421	APPLIED HEAT TRANSFER	3-0-0: 3

Pre-Requisites: Heat transfer

Course Outcomes:

CO1	Understand the heat transfer alteration requirement in industry
CO2	Understand the basics for air, liquid and two phase cooling
CO3	Understand the basics of insulation
CO4	Select appropriate heat transfer techniques and devices for a given application

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus

Introduction: Introduction to requirement of heat transfer alteration. Overview of heat generation components and processes in electric vehicle, gas turbine, electronic and electrical systems.

Air cooling: Active and passive methods, flow through channels, jet impingement, film cooling, wall jet etc. Application in industry.

Liquid cooling: Basics of microfluidics, mini channel flow, nano-fluids, types of fluids. Application in industry

Two phase cooling: Two phase flow basics. Heat pipe – working, mathematical modelling, types of heat pipe. Phase change material – introduction, modelling, types. Application in industry

Insulation: Basic derivations, types, application in industry.

Textbooks

1. Gas Turbine Heat Transfer and Cooling Technology, Je-Chin Han, Sandip Dutta, and Srinath Ekkad, CRC Press, 2000
2. Thermal Design of Liquid Cooled Microelectronic Equipment, Lian-Tuu Yeh, ASME Press 2019
3. Heat Pipe Design and Technology- A Practical Approach, Bahman Zohuri, CRC Press 2011

Online Resources

1. https://nptel.ac.in/courses/112/107/112107207/
2. https://nptel.ac.in/courses/112/106/112106169/

Course Code: ME422	GAS DYNAMICS	3-0-0: 3

Prerequisites: NIL

Course Outcomes:

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:

	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

Syllabus:

Introduction: Review of basic fluid dynamic and thermodynamic principles, Conservation equations for inviscid 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

Learning Resources:

Textbooks:

1. Anderson, J.D Jr., Modern Compressible Flows, Tata McGraw Hill, 2017
2. Yahya, S.M., Fundamentals of Compressible Flow, New age International Pub., 2018
3. Zucrow, M., Gas Dynamics, Wiley India, 2013

Course Code: ME423	ARTIFICIAL INTELLIGENCE FOR CYBER PHYSICAL SYSTEMS	3-0-0: 3

Prerequisites: NIL

Course Outcomes:

CO1	Understand the core concepts of Cyber Physical Systems and Industry 4.0
CO2	Apply AI, ML and Deep Learning concepts to Manufacturing Systems
CO3	Apply the IoT and IIoT concepts on Cyber Physical Systems
CO4	Examine the Sensors, actuators and their performance using simulation and experimental analysis
CO5	Evaluate the Digital twins for a given case study

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Module 1: Industry 4.0, and its Key issues; Models for Cyber Physical Systems.

Module 2: Introduction of Artificial Intelligence, Machine Learning and Deep learning components; Overview of supervised and unsupervised learning.

Module 3: CPS HW platforms: Processors, Sensors, Actuators, CPS Network, CPS SW stack RTOS, Scheduling Real Time control tasks; Basic Data formats, databases and operations; Statistics and probability basics, regression and correlation; Server client programming; Communication using WIFI, Bluetooth, WANs. Introduction cloud computing and Fog computing.

Module 4: Introduction to Raspberry Pi; Installation, controlling and integrating of Raspbian OS on Raspberry Pi with different sensors; Data acquisition using Raspberry Pi; Analysis of stateflow implementation using Matlab toolboxes, and Mapping software components to ECUs.

Module 5: Introduction of Digital twins; architectures, frameworks; Systematic approach for implementation of Digital twins in organizations; Case studies: AI and CPS approaches on various cases of Manufacturing Systems.

Text Books:

1. Cyber-Physical Systems, Rajkumar, Dionisio De Niz and Mark Klein, Wesley Professional.
2. Principles of Cyber-Physical Systems, Rajeev Alur, MIT Press, 2015.
3. A Comprehensive guide to AI and Expert Systems, Robert Levine, McGraw Hill Inc, 1986.
4. Introduction to Embedded Systems: A Cyber-Physical Systems Approach, E. A. Lee and S. A. Seshia, 2011.
5. Introduction to Discrete Event Systems, C. Cassandras, S. Lafortune , Springer 2007.
6. Formal methods for real-time computing, Constance Heitmeyer and Dino Mandrioli, Wiley publisher, 1996.

Course Code: ME424	MICRO AND NANO MANUFACTURING	3-0-0: 3

Prerequisites: NIL

Course Outcomes:

CO1	Understand manufacturing considerations at the micro and nano scale
CO2	Characterize nanostructures for a particular industrial application
CO3	Select suitable manufacturing methods to create micro sized components
CO4	Design industrially-viable processes, equipment and manufacturing tools for specific industrial products

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: Importance of Nano-technology, Emergence of Nanotechnology, Bottom-up and Top-down approaches, challenges in Nanotechnology, Scaling Laws/Sizing effects.

Nano-materials Synthesis and Processing: Methods for creating Nanostructures; Processes for producing ultrafine powders- Mechanical grinding; Wet Chemical Synthesis of nano-materials- sol-gel process, Liquid solid reactions; Gas Phase synthesis of nano-materials- 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).

Micro fabrication Techniques: Lithography, Thin Film Deposition and Doping, Etching and Substrate Removal, Substrate Bonding, MEMS Fabrication Techniques, Bulk Micromachining, 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. Honing and Lapping nano-finishing processes. Abrasive flow finishing process and variants, Elastic emission machining, Elasto abrasive finishing, Focused ion beam nano finishing for ultra-thin TEM sample preparation

Hybrid Nano finishing Process: Electrochemical grinding, electrochemical magnetic abrasive finishing, Electro discharge diamond grinding, Fine finishing of gears by electrochemical honing process and Ultrasonic assisted abrasive flow machining

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 Tunnelling Microscopy (STM), Atomic force Microscopy (AFM).

MEMS devices and applications: Pressure sensor, inertial sensor, Optical MEMS and RF-MEMS, Micro-actuators for dual-stage servo systems.

Text Books:

1. MEMS and Microsystems: Design and Manufacture ,Tai-Ran Hsu, McGraw- Hill, 2008
2. Fundamentals of Microfabrication: The Science of Miniaturization Marc Madou, , Second Edition CRC Press, 2002.
3. Microfabrication and Nanomanufacturing , Mark James Jackson, , CRC Press, 2005.

Reference Books:

1. Introduction to Nanoscience and Nanotechnology,Gabor L. Hornyak, H.F Tibbals, Joydeep Dutta & John J Moore, CRC Press, 2009.
2. Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM, Ray F. Egerton, , Springer, 2005.
3. Thermal Analysis of Materials, Robert F Speyer, , Marcel Dekker Inc , New York, 1994.
4. Elements of X-Ray Diffraction, B.D. Cullity, 3 rd edition, Prentice Hall , 2002.

Online Resources:

1. https://asmedigitalcollection.asme.org/micronanomanufacturing
2. https://nptel.ac.in/noc/courses/noc19/SEM2/noc19-bt29/

Course Code: ME425	SUPPLY CHAIN MANAGEMENT	3-0-0: 3

Prerequisites: NIL

Course Outcomes:

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

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PS02
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	3	3		3	3	2	2	3	2	2	2	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

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

Text Books:

1. Supply Chain Management - Strategy, Planning and Operation, Sunil Chopra and Peter Meindl, 6th Edition, Pearson Education Asia, 2016.
2. Designing and Managing the Supply Chain - Concepts Strategies and Case Studies, David Simchi-Levi, Philp Kamintry and Edith Simchy Levy, 3rd Edition, TMH, 2008

Reference Books:

1. Supply Chain Management – Text and Cases, Janat Shah, Second Edition, Pearson, 2016.
2. Supply Chain Metrics That Matter, Lora M. Cecere, Wiley, First Edition, 2015.

3. Modeling the Supply Chain, Jeremy F Shapiro, Second Edition, Thomson, 2007.

Online Resources:

1. https://ocw.mit.edu/courses/engineering-systems-division/esd-273j-logistics-and-supply-chain-management-fall-2009/index.htm

Course Code: ME426	MATERIAL CHARACTERIZATION	3-0-0: 3

Prerequisites: NIL

Course Outcomes:

CO1	Identify advanced techniques available for characterization of materials
CO2	Select constituent materials for producing a given composite
CO3	Analyze defects and failure surfaces of materials
CO4	Select a characterization technique for evaluating the behavior of materials

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PS02
CO1	2	2	3	2	3	1	2			2	3	3	2	3
CO2	2	2	3	2	3	1	2			2	3	3	2	3
CO3	3	2	3	2	3	1	2			2	3	2	2	3
CO4	3	2	3	2	3	1	2			2	3	2	2	3

Syllabus:

Introduction:
Overview of the course, material classification- metals and alloys, ceramics, polymers and composites, Importance of materials selection, property classification, Criteria for selection of materials, Ashby charts for materials selection

Introduction to Materials Characterization Techniques-
Different techniques and their purposes; Introduction, Principle, construction and operation. Sample preparation for all the characterization.

Physical characterization of materials;
Optical Microscopy, SEM,TEM, Density, Void content in materials,Electron Probe Micro Analyzer (EPMA), Atomic Force Microscopy (AFM), Thermogravimetric analysis (TGA), nano indentation, NMR spectroscopy, EDAX, FTIR, XRD

Mechanical characterization:
Tensile test, flexural test, compression test, ILSS, creep, fatigue, Hardness, Impact test, Fracture toughness test, Principle, construction and operation working parameters, equipment operation.

Tribological characterization:
Abrasive wear, Pin-on Disc, Erosion test, Corrosion test, sand abrasion, slurry erosion, scratch test, nano indent scratch test,

Learning Resources:

Text Books:

1. Materials Selection in Mechanical Design, M.F. Ashby, Butterworth Heinemann, 2005
2. Materials Characterization-Introduction to Microscopic and Spectroscopic Methods, Yang Leng, John Wiley & Sons (Asia) Pte Ltd, 2008

3. ASM Handbook: Materials Characterization, ASM International, 2008

Reference Books:

1. V. T. Cherapin and A. K. Mallik: Experimental Techniques in Physical Metallurgy, Asia Publishing House, 1967.
2. George E. Dieter, Mechanical Metallurgy, McGraw Hill, 2nd Edition, 2005

Course Code: ME427	FRACTURE MECHANICS	3-0-0: 3

Prerequisites: NIL

Course Outcomes:

CO1	Understand the concept of crack propagation leading to fracture failure.
CO2	Analyze the fracture strength of mechanical components under different fracture modes.
CO3	Apply fracture mechanics principles for determining Fracture Parameters using Experimental Methods.
CO4	Design mechanical components against fracture
CO5	Analyze the mechanical components against fracture through Non-Destructive Testing.

Course Articulation Matrix:

	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							2	2	2
CO4	3	3	2	2	3							3	2	3
CO5	3	3	2	3	3							2	2	2

Syllabus:

Introduction: Brittle and Ductile Fracture, Modes of Fracture Failure, Surface Energy, Griffith's Dilemma, Realization and Analysis. Energy Release Rate, Energy Release Rate of DCB Specimen, Anelastic Deformation at Crack-tip, Crack Resistance, Stable and Unstable Crack Growth, Critical Energy Release Rate.

Stress Intensity Factor: Linear Elastic Fracture Mechanics (LEFM), Stress and Displacement Fields in Isotropic Elastic Materials, Westergaard's Approach.

SIF of More Complex Cases: Applications of Westergaard Approach, Crack in a Plate of Finite Dimensions, Edge Cracks, Embedded Cracks, The Relation between GIand KI, Critical Stress Intensity Factor.

J-Integral: Definition of the J-Integral, Path Independence, Stress-Strain Relation, Experiments to Determine the Critical J-Integral,Comments on the Numerical Evaluation ofJ-Integral, A Simplified Relation for the J-Integral, Applications to Engineering Problems.

Test Methods: KIC-Test Technique, Test Methods to Determine JIC ,Test Methods to Determine GIC and GIIC ,Determination of Critical CTOD.

Fracture Parameters: Direct Methods to Determine Fracture Parameters. Indirect Methods to Determine Fracture Parameters. Mixed Mode Crack Initiation and Growth.

Crack Detection through Non-Destructive Testing: Examination through Human Senses, Liquid Penetration Inspection, Ultrasonic Testing, Radiographic Imaging, Magnetic Particle Inspection.

Learning Resources:

Text Books:

1. Elements of fracture mechanics, Kumar, Prashant, Tata McGraw-Hill Education, 2009

Reference Books:

1. Fracture mechanics: fundamentals and applications, Anderson, Ted L., CRC press, 2017
2. Elementary engineering fracture mechanics, Broek, David, Springer Science & Business Media, 2012
3. Fracture and Fatigue control in Structures, S.T. Rolfe and J.M. Barson, Prentice Hall Inc. New Jersy, 1977
4. Advanced Fracture Mechanics, M.F. Kanninen and C.H. Popelar, Oxford University Press, 1985
5. Nonlinear Fracture Mechanics, J.W. Hutchinson, Department of Solid Mechanics, The Technical University of Denmark Publications, 1979
6. Fracture mechanics: Fundamentals and applications. Maiti, Surjya Kumar, Cambridge University Press, 2015

IV YEAR, II-Semester

Course Code: ME498	SEMINAR	0-0-2: 1

Prerequisites: NIL

Course Outcomes:

CO1	Identify technical and practical issues related to the area of course specialization.
CO2	Outline annotated bibliography of research demonstrating scholarly skills
CO3	Prepare a well-organized report employing elements of technical writing and critical thinking
CO4	Demonstrate the ability to describe, interpret and analyze technical issues and develop competence in presenting.

Course Articulation Matrix:

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

Evaluation Scheme:

Task	Description	Weightage
1	Clarity on the topic	10
2	Literature survey	30
3	Content	30
4	Presentation	20
5	Response to questions	10
Total		100

Course Code: ME499	PROJECT WORK	0-0-8: 4

Prerequisites: NIL

Course Outcomes:

CO1	Identify a topic in advanced areas of Mechanical Engineering
CO2	Review literature to identify gaps and define objectives & scope of the work.
CO3	Develop a prototype/model, experimental set-up and software systems to meet the objectives
CO4	Analyze the results to draw valid conclusions
CO5	Explore the possibility of publishing papers in peer reviewed journals/conference Proceedings

Course Articulation Matrix:

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

Syllabus:

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.
	Team Work	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

Department Elective-V

Course Code: ME461	POWER PLANT ENGINEERING	3-0-0: 3

Pre-Requisites: Thermodynamics

Course Outcomes:

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 and environmental implications on power plants.

Course Articulation Matrix:

	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

Syllabus:

Introduction: Energy resources and their availability, types of power plants, review of basic thermodynamic cycles used in power plants.

Steam Power Plants: Flow sheet and working of modern-thermal power plants, site selection, plant efficiency

Steam generators and their accessories: High pressure Boilers and its accessories, Draught system.

Fuel and combustion: coal storage, preparation, coal handling systems, mass and energy balance of steam generator, feeding and burning of pulverized fuel, Fluidized bed combustion system, ash handling systems, dust collection-mechanical dust collector and electrostatic precipitator.

Condensers: Direct Contact Condenser, Surface Condensers, Cooling towers and cooling ponds

Combined Cycles: Gas turbine power plants, integrated gasification combined cycle, PFBC based combined cycle, re-powering of thermal power plant.

Nuclear Power Plants: Principles of nuclear energy, basic nuclear reactions, nuclear cross-section, and different components of nuclear power station, PWR, BWR, fast breeder, nuclear waste disposal.

Non-conventional energy generation: Geothermal power plant, Tidal and wave power plant, solar power plant, wind power generation, direct to electricity method - Magneto-hydrodynamic (MHO) power generation

Hydro Electric Power Plants: Rainfall and run-off measurements and plotting of various curves for estimating stream flow and size of reservoir, power plant design, comparison with other types of power plants.
Power Plant Economics: load curve, different terms and definitions, base load and peak load plants, energy storage, cost of electricalenergy, tariffs methods of electrical energy,

performance & operating characteristics ofpower plants- incremental rate theory, input-output curves, efficiency, heat rate, economic load sharing, Problems.

Learning Resources:

Text Books:

1. Power Plant Engineering, P. K. Nag, McGraw Hill Education, 4th Edition, 2017
2. Power plant engineering, Arrora, Domkundwar, DhanpatRai & Sons, New Delhi, 2008
3. Power plant engineering, P. C. Sharma, S.K. Kataria & Sons, New Delhi, 2010

Reference Books:

1. Power plant Technology, M.M.Ei-Wakil, McGraw Hill Com., 1985

Online Resources:

1. https://www.alternative-energy-tutorials.com/

Course Code: ME462	TWO-PHASE HEAT TRANSFER	3-0-0: 3

Pre-Requisites: Heat transfer

Course Outcomes:

CO1	Understand the fundamentals of two-phase flow
CO2	Analyze flow regimes with appropriate models
CO3	Understand pool boiling and flow boiling
CO4	Measure parameters in multi-phase flow

Course Articulation Matrix:

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

Syllabus:

Hydrodynamics of two-phase flow: Introduction to multiphase flow, types and applications, Common terminologies, flow patterns and flow pattern maps. One dimensional steady homogenous flow, Concept of choking and critical flow phenomena, The separated flow model for stratified and annular flow, General theory of drift flux model, Application of drift flux model to bubbly and slug flow, Pressure Drop in Two-Phase Flow. Measurement techniques for multiphase flow, void fraction and flow rate measurement.

Pool and flow boiling: Description and Classification of Boiling, Pool Boiling Curve, Nucleation and Dynamics of Single Bubbles, Heat Transfer Mechanisms in Nucleate Boiling, Nucleate Boiling Correlations, Hydrodynamic of Pool Boiling Process, Pool Boiling Crisis, Film Boiling Fundamentals, Flow Boiling, Forced-Flow Boiling Regimes, Nucleate Boiling in Flow, Sub-cooled Nucleate Flow Boiling, Saturated Nucleate Flow Boiling, Flow Boiling Correlations, Flow Boiling Crisis.

Condensation: Film and dropwise condensation.

Text Books:

1. Boiling Heat Transfer and Two-Phase Flow, L. S. Tong and Y. S. Tang, Taylor and Francis, 1997
2. Convective boiling and condensation, J. B. Collier, and J. R. Thome, Oxford Science Publications, 1994

Reference Books:

1. C.E. Brennen, Fundamentals of Multiphase Flow, Cambridge University Press, New York, 2005.

Course Code: ME463	MACHINE TOOL DESIGN	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Design kinematic motions in a machine tool.
CO2	Design 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:

	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

1 - Slightly; 2 - Moderately; 3 – Substantially

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.

Text Books:

1. Machine Tool Design and Numerical Control, N.K. Mehta, TMH, New Delhi, 2010
2. Principles of Machine Tools, G.C. Sen and A. Bhattacharya**,** New Central Book

Agency, 2009

Reference Books:

1. Design of Machine Tools, D. K Pal, S. K. Basu, Oxford IBH, 2008, 5th Edition
2. Machine Tool Design, Vol. I, II, III and IV, N. S. Acherkhan, MIR publications, 1968

Course Code: ME464	ADDITIVE MANUFACTURING PROCESSES AND APPLICATIONS	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Understand the working principle and process parameters of AM processes
CO2	Explore the applications of AM processes in various fields
CO3	Apply the suitable process and material for fabricating a given product
CO4	Use the suitable post process based on product application
CO5	Design and develop a product for AM Process

Course Articulation Matrix:

	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
CO5	2	2			2								3	2

Syllabus:

Introduction to Additive Manufacturing: Introduction to AM, AM evolution, Distinction between AM & CNC machining, Steps in AM, Classification of AM processes, Advantages of AM.

Materials for AM: Atomic Structure and Bonding, Nature of Polymers, Thermoplastics and Thermosetting Polymers, Types of Polymerizations, Properties of Polymers, Degradation of Polymers, Metal and Ceramic Powders, Composites, Functionally Graded Materials (FGM's).

Liquid state-based 3D printing Process: Stereo lithography apparatus (SLA): Models and specifications, process, working principle, photopolymers, Micro-stereolithography, photo polymerization, layering technology, laser and laser scanning, applications, advantages and disadvantages, case studies. Solid ground curing (SGC): Models and specifications, process, working, principle, applications, advantages and disadvantages, case studies.

Solid state-based 3D printing Processes: Laminated object manufacturing (LOM): Models and specifications, Process, Working principle, Applications, Advantages and disadvantages, Case studies. Fused Deposition Modeling (FDM): Models and specifications, Process, Working principle, Applications, Advantages and disadvantages, Case studies, practical demonstration. Friction stir additive manufacturing**:** process, parameters, advantages, limitations and applications, Additive friction stir deposition process: principle, parameters, applications, functionally graded additive manufacturing components, Ultrasonic Consolidation (UC), Gluing, Thermal bonding, LOM and UC applications. Wire Arc Additive Manufacturing: Process, parameters, applications, advantages and disadvantages, case studies.

Powder Based 3D printing Processes: Selective laser Sintering (SLS), Materials, Powder fusion mechanism and powder handling, Process Modelling, SLS Metal and ceramic part creation, Electron Beam melting (EBM), Process Benefits and Drawbacks, Applications of Powder Bed Fusion Processes.

Directed Energy Deposition Processes: Process Description, Material Delivery, Laser Engineered Net Shaping (LENS), Direct Metal Deposition (DMD), Electron Beam Based Metal Deposition, Processing-structure-properties, relationships, Benefits and drawbacks, Applications of Directed Energy Deposition Processes, case studies, Binder Jetting AM Process:process, applications

Additive Manufacturing Printing Applications: Applications in prototyping, concept models, visualization aids, replacement parts, tooling, jigs & fixtures, moulds, casting, and end-use parts, Industrial Applications in aerospace, automobile, medical, jewelry, sports, electronics, food, construction and architectural.

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.

Learning Resources:

Text Books:

1. Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, Ian Gibson, David W Rosen, Brent Stucker, Springer, 2015, 2nd Edition.
2. 3D Printing and Additive Manufacturing: Principles & Applications, Chua Chee Kai, Leong Kah Fai, World Scientific, 2015, 4th Edition.

Reference Books:

1. Rapid Prototyping: Laser-based and Other Technologies, Patri K. Venuvinod and Weiyin Ma, Springer, 2004.
2. Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, D.T. Pham, S.S. Dimov, Springer 2001.
3. Rapid Prototyping: Principles and Applications in Manufacturing, Rafiq Noorani, John Wiley & Sons, 2006.
4. Additive Manufacturing, Second Edition, Amit Bandyopadhyay Susmita Bose, CRC Press Taylor & Francis Group, 2020.
5. Additive Manufacturing: Principles, Technologies and Applications, C.P Paul, A.N Junoop,McGrawHill, 2021.

Online Resources:

1. https://www.nist.gov/additive-manufacturing
2. https://www.metal-am.com/
3. http://additivemanufacturing.com/basics/
4. https://www.3dprintingindustry.com/
5. https://www.thingiverse.com/
6. https://reprap.org/wiki/RepRap

Course Code: ME465	PROJECT MANAGEMENT	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

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:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PS02
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	2	3	3
CO5	3	3	3	3	2						3	2	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: Introduction to Project Management, History of Project Management, Project Life Cycle.

Project Analysis: Facets of Project Analysis, Strategy and Resource Allocation, Market and Demand Analysis, Technical Analysis, Economic and Ecological Analysis.

Financial Analysis: Financial Estimates and Projections, Investment Criteria, Financing of Projects.

Network Methods in PM: Origin of Network Techniques, AON and AOA differentiation, CPM network, PERT network, other network models.

Optimisation 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.

Text Books:

1. Project: A Planning Analysis, Prasanna Chandra, Tata McGraw Hill Book Company, New Delhi, 2009, 4th Edition.
2. Project Management, Cleland, Gray and Laudon,Tata McGraw Hill Book Company, New Delhi, 2007, 3rd Edition.
3. Project Management - A Managerial Approach, Jack R. Meredith and Samuel J., Jr. Mantel, John Wiley, 2011, 6th Edition.

Reference Books:

1. The Critical Chain, Eliyahu M Goldratt, Business novel, 1997
2. A guide to the Project Management Body of Knowledge, Fourth Edition, Project Management Institute, 2008

Online Resources:

1. https://www.pmi.org/
2. https://www.pma-india.org/pma-cert/

Course Code: ME466	LUBRICATION AND ROTOR DYNAMICS	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Identify the proper lubricant for a given application.
CO2	Determine the lubrication regime for the rotor-bearing system
CO3	Model the Rotor bearing systems and formulate the governing equations.
CO4	Compute the critical speeds and stability limits for rotors under axial, transverse and torsional modes.
CO5	Analyse the rotor bearing systems using transfer matrix method and Finite Element Method.

Course Articulation Matrix:

	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							2	2	2
CO4	3	3	2	2	3							3	2	2
CO5	3	3	2	2	3							3	2	3

Syllabus:

Introduction: Rotating machinery, Technology of friction control and wear prevention in rotating machinery, Properties and testing of lubricants. Bearing Systems: Rolling element bearings, Hydrodynamic oil-journal bearings, Gas lubricated bearings, Hydrostatic bearings and Squeeze film bearings.

Lubricants and Lubrication: Physical properties of lubricants, Viscosity index, Viscosity measurement, Temperature characteristics of lubricants, Different lubrication regimes and Stribeck Curve, Derivation of 2D Reynold's equation, Mechanism of pressure development in lubrication, Theories of Hydrostatic lubrication, Squeeze film lubrication and Gas lubrication.

Linear Rotor Dynamics : Equation of motion, Rotating systems, Complex coordinate representation, Jeffcott Rotor – Free whirling, Unbalance response, Shaft Bow With structural damping.

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, Computation of critical speeds, Computation of unbalance response. Campbell and root locus diagrams, Reduction of DOF: Nodal reduction, model reduction and component mode synthesis.

Torsional and Axial Dynamics: Free and forced Torsional vibrations and critical speeds, Axial Vibration of rotors.

Learning Resources:

Text Books:

1. Fluid film lubrication theory and design, Andras Z. Szeri, Cambridge University press, 1998.
2. Theory of Lubrication, Majumdar B.C, Mihir Sarangi, M K Ghosh, Tata McGraw Hill Education Private Limited, 2013.
3. Dynamics of Rotating Systems, Giancarlo Genta, Springer, 2009.

Reference Books:

1. Basic lubrication theory, Cameron A, Ellis Horwood Ltd., 2002.
2. Rotor Dynamics, Rao, J.S., New Age International, 2003, 3rd Edition
3. Rotating Machinery Vibrations, Marcel Dekker, Inc., New York, 2001

Department Elective - VI

Course Code: ME471	FUEL CELL TECHNOLOGY	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Understand fuel cell fundamentals
CO2	Analyse the performance of PEM fuel cell system
CO3	Demonstrate the operation of fuel cells
CO4	Apply the modelling techniques for fuel cell systems

Course Articulation Matrix:

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

Syllabus:

Overview of Fuel Cells: Description of fuel cell, brief history, classification, working principle, Fuel cell basic chemistry and thermodynamics of fuel cell and performance.

Fuel Cell Thermodynamics: Thermodynamic Potentials, Heat Potential of a Fuel: Enthalpy of reaction, Reaction Enthalpies, Work Potential of a Fuel: Gibbs Free Energy, Relationship between Gibbs Free Energy and Electrical Work, Computing Reversible Voltages, Reversible Voltage Variation with Temperature, Reversible Voltage Variation with pressure, Reversible Voltage Variation with concentration: Nernst Equation, Fuel Cell Efficiency-Ideal and real fuel cell efficiency.

Fuel cell electrochemistry: electrode kinetics, types of voltage losses, polarization curve, fuel cell efficiency, Tafel equation, exchange currents.

Fuel Cell Modeling: A Basic Fuel Cell Model, 1-D PEM Fuel Cell Model,

Fuels for Fuel Cells: Hydrogen, Hydrocarbon fuels, effect of impurities such as CO, S and others, hydrogen generation and storage; limitations, recent advances.

Overview of fuel cell types: Phosphoric acid fuel cell (PAFC), Polymer electrolyte membrane fuel cell (PEMFC), Alkaline fuel cell (AFC), Molten carbonate fuel cell (MCFC), Solid-oxide fuel cell (SOFC) and other fuel cells.

PEM Fuel cell components: Main PEM fuel cell components, materials, properties and processes: membrane, electrode, gas diffusion layer, bi-polar plates, flow field plate design, Fuel cell operating conditions: pressure, temperature, flow rates, humidity. **Direct methanol fuel cell**, active and passive DMFC, methanol cross over and techniques to reduce, current collectors.

Main components of solid-oxide fuel cells, Cell stack and designs, Electrode polarization,

testing of electrodes, cells and short stacks, Cell, stack and system modelling.

Fuel processing: Direct and in-direct internal reforming, Reformation of hydrocarbons by steam, CO_2 and partial oxidation, Direct electro-catalytic oxidation of hydrocarbons, carbon decomposition, Sulphur tolerance and removal , Using renewable fuels for SOFCs.

Learning Resources:

Text Books:

1. Fuel Cell Fundamentals, Ryan O′Hayre, Suk-Won Cha Whitney Colella second edition,
2. John Wiley & Sons, 2018.
3. PEM Fuel Cells: Theory and Practice, Franno. Barbir, (2nd Ed.) Elsevier/Academic Press, 2013.

Reference Books:

1. Fuel Cells and Their Applications, Karl Kordesch& Gunter Simader, VCH Publishers, 2001
2. Fuel Cell Technology Hand Book, Hoogers G., , CRC Press, 2010

Course Code: ME472	JET PROPULSION AND ROCKETRY	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Understand the principles of Rocket propulsion
CO2	Analyze the performance of Rocket components
CO3	Select suitable solid, liquid and hybrid propellants for specific application
CO4	Evaluate the performance of Rocket engines

Course Articulation Matrix:

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

Syllabus:

Jet Propulsion Cycles and their Analysis: Criteria of Performance, Simple Turbojet Engine, Simple Turbofan Engine, Simple Turboprop Engine, Turbo-shaft Engine, Thrust Augmentation Techniques

Fundamentals of Rotating Machines: General Fluid Dynamic Analysis, Euler's Energy Equation, Components of Energy Transfer, Impulse and Reaction Machines

MOTION IN SPACE: REQUIREMENT FOR ORBIT:
Motion of Bodies in space, Parameters describing motion of bodies, Newton's Laws of motion, Universal law of gravitational force, Gravitational field, Requirements of motion in space, Geosynchronous and geostationary orbits, Eccentricity and inclination of orbits, Energy and velocity requirements to reach a particular orbit, Escape velocity, Freely falling bodies, Means of providing the required velocities

THEORY OF ROCKET PROPULSION
Illustration by example of motion of sled initially at rest, Motion of giant squid in deep seas, Rocket principle and rocket equation, Mass ratio of rocket, Desirable parameters of rocket, Rocket having small propellant mass fraction, Propulsive efficiency of rocket, Performance parameters of rocket, Staging and clustering of rockets, Classification of rockets.

ROCKET NOZZLE AND PERFORMANCE
Expansion of gas from a high pressure chamber, Shape of the nozzle, Nozzle area ratio, Performance loss in conical nozzle, Flow separation in nozzles, Contour or bell nozzles, Unconventional nozzles, Mass flow rates and characteristics velocity, Thrust developed by a rocket; Thrust coefficient, Efficiencies, Specific impulse and correlation with C* and CF, General Trends.

SOLID PROPELLANTS, LIQUID PROPELLANTS, AND HYBRID ROCKETS:
Working principle, Choice of fuels and oxidizer, Mechanism of burning and burn rate

Learning Resources:

Text Books:

1. Rocket Propulsion, Barrere, M., Elsevier Pub. Co., 1990.
2. Rocket Propulsion Elements, Sutton, G. P., John Wiley, New York, 1993.
3. Rocket Propulsion, Ramamurthi K., Macmillan Publishers India Ltd., 2010
4. Introduction to Rocket Technology, Feedesiev, V. I. and Siniarev, G. B., Academic Press, New York, 2000.
5. Gas Turbine Theory, Sarvanamuttoo, H.I.H., Rogers, G. F. C. and Cohen, H., Pearson PrenticeHall, 2008, 6th Edition

Course Code: ME473	RELIABILITY ENGINEERING	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Understand the concepts of reliability, availability and maintainability
CO2	Develop hazard-rate models for understanding the behaviour of components
CO3	Build system reliability models for different configurations.
CO4	Asses 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:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PS02
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	

1 - Slightly; 2 - Moderately; 3 – Substantially

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.

Text Books:

1. An Introduction to Reliability and Maintainability Engineering, Ebeling C. E, TMH, New Delhi, 2004
2. Practical Reliability Engineering, O'Connor P and Kleymer A, Wiley, 2012

Course Code: ME474	DESIGN FOR MANUFACTURING AND ASSEMBLY	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

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:

	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

1 - Slightly; 2 - Moderately; 3 – Substantially

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 sand castings, Example calculations, Investment casting overview, Cost estimation, Number of parts per cluster, Ready to pour liquid metal cost, Design guide lines 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 metalworking: 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 of a systematic DFA analysis method, DFA index, classification system for manual handling, Manual insertion and Fastening.

Text Books:

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.

Reference Books:

1. ASM Handbook, “Design for manufacture”, 2000.

Online Resources:

1. https://nptel.ac.in/courses/112/101/112101005/

Course Code: ME475	ADVANCED MATERIALS PROCESSING	3-0-0: 3

Pre-Requisites: Manufacturing Science

Course Outcomes:

CO1	Understand the different processing techniques for engineering materials.
CO2	Analyze the kinetics of structural changes for developing processing maps
CO3	Utilize appropriate manufacturing methods for powder metallurgical components.
CO4	Apply laser for processing of engineering materials.

Course Articulation Matrix:

	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

Syllabus:

Introduction: Materials history and character - Family trees: organizing materials and processes - Introduction to Materials Processing – Approaches – Processing steps – Processing of Metals, Ceramics and Polymers.

Equilibrium constitution and phase diagrams -Mixing elements to make an alloy - Examples: the lead–tin, copper–nickel and copper–zinc alloy systems; Examples

Processing of Metallic materials: Introduction to solidification process, single crystal and poly crystalline materials - Driving force for structural change - Work done during a structural change Driving force for the change; examples: solid-state phase changes, precipitate coarsening, grain growth, recrystallisation; sizes of driving forces; examples

Kinetics of structural change: I – Diffusive transformations - Driving force and thermal activation - Latent heat and diffusion - slow transformations; examples

Kinetics of structural change: II – Nucleation - Nucleation in liquids and solids; why nucleation is helped by solid catalysts; Examples: nucleation in plants, vapour trails, bubble chambers and caramel; Examples

Kinetics of structural change: III – Displacive transformations - Avoiding diffusive transformations by rapid cooling – Displacive (shear) transformations – Examples

Laser processing of materials: Mechanisms of Laser Processing of Metal Surfaces - Thermal Model of Laser Hardening of the Steel Surface - Hydrodynamical Models of Laser-Induced Alloying of Metal Surfaces - Mechanisms of Laser-Induced Surface Cleaning - Modelling of Selective Laser Melting

Powder Processes – Powder characteristics – Sintering and Microstructure development - Post-Forming Processes for Green Parts

Learning Resources:

Text Books:

1. Engineering Materials 2 An Introduction to Microstructures, Processing and Design, Michael F. Ashby and David R. H. Jones, Elsevier, 2006, , 3rd Edition
2. Physics of Laser Materials Processing Theory and Experiment, Gennady G. Gladush Igor Smurov, Springer, 2011
3. Materials Processing: A Unified Approach to Processing of Metals, Ceramics and Polymers, Lorraine F. Francis, Bethanie J. H. Stadler , Christine C. Roberts, Elsevier, 2015

Reference Books:

1. Materials: engineering, science, processing and design, Mike Ashby, Hugh Shercliff, and David Cebon,Elsevier, 2019, 4th edition

Course Code: ME476	ENGINEERING ACOUSTICS	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

CO1	Understand wave propagation, absorption, transmission, reflection and radiation.
CO2	Formulate acoustic problems for reduction of sound levels.
CO3	Design resonant systems including pipes, mufflers, Helmholtz resonators.
CO4	Evaluate architectural acoustics reverberation time, direct echoes and acoustical amplification.
CO5	Analyse the acoustic levels and analytical predictions.

Course Articulation Matrix:

	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

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.

Learning Resources:

Text Books:

1. Introduction to acoustics, Robert D Finch., PHI2008
2. Engineering Acoustics: An introduction to Noise Control, 2/e, Springer, 2009 Michael Moser, Michael Maser, S. Zimmermann, Springer, 2009.
3. Foundations of Engineering Acoustics, Frank J Fahy, Academic Press, 2000.
4. Fundamentals of Acoustics L. E. Kinsler, A R. Frey, A B. Coppens and J V. Sanders, Wiley Publishers, 2005.

Online Resources:

1. https://nptel.ac.in/courses/112/104/112104212/

Course Code: ME477	MECHANICS OF COMPOSITE MATERIALS	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

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:

	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

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 behaviour 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 behaviour 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 behaviour, Inter-laminar stresses, transverse shearing, Laminate optimization

Learning Resources:

Text Books:

1. Principles of composite material mechanics, Ronald F. Gibson, CRC Press, 2011.
2. Mechanics of Composite Materials, Robert M Jones, Taylor & Francis, 2000.

Reference Books:

1. Lawrence E. Nielsen, Nielson, Paul Nielsen, Mechanical Properties of Polymers and Composites, Second Edition, CRC press, 2000