Dr. Babasaheb Ambedkar Technological University

(Established as a University of Technology in the State of Maharashtra)

(under Maharashtra Act No. XXIX of 2014)

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Course Structure and Contents

for

M.Tech. in Mechanical Engineering

From 1st Semester - 4th Semester

Vision

The vision of the Department is to achieve excellence in teaching, learning, research and transfer of technology and overall development of students.

Mission

Imparting quality education, looking after holistic development of students and conducting need-based research and extension activities.

Post Graduate Attributes

The Post Graduate Attributes are the knowledge skills and attitudes which the students have at the time of post-graduation. The Post Graduate Attributes identified by National Board of Accreditation are as follows:

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

Programme Educational Objectives (PEOs)

No.	PEO
PEO1	To train students withindepth and advanced knowledge to become professional and capable of identifying, analyzing and solving complex problems in the areas of Heat power engineering.
PEO2	To enable post graduates to carry out innovative and independent research work, disseminate the knowledge in Academia/Industry/Research Organizations to develop systems and processes in the related field.
PEO3	To prepare the students to exhibit a high level of professionalism, integrity, effective communication skills and environmental and social responsibility.
PEO4	To provide an academic environment that gives adequate opportunity to the students to cultivate life-long independent learning ability for their successful professional career.

Programme Outcomes (POs)

At the end of the program, the students will be able to:

No.	PO

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Abbreviations

PEO:	Program Educational Objectives
PO:	Program Outcomes
CO:	Course Outcomes
L:	No. of Lecture hours (per week)
T:	No. of Tutorial hours (per week)
P:	No. of Practical hours (per week)
C:	Total number of credits
BSH:	Basic Science and Humanity
BSC:	Basic Sciences Course
PCC:	Professional Core Course
OEC:	Open Elective Course
PEC:	Professional Elective Course
BHC:	Basic Humanity Course
ESC:	Engineering Science Course
HSMC:	Humanity Science and Management Course
NCC:	National Cadet Corps
NSS:	National Service Scheme

MASTER OF TECHNOLOGY
(Mechanical Engineering)

Syllabus with effect from July 2018

Semester-I

Course Code	Type of Course	Name of the Course	Hours/Week			Credit	Examination Scheme				
							Theory		CA	PR/OR	Total
			L	T	P		TH	Test			
MMECH11	PCC	Engineering Thermodynamics	3	1	--	4	60	20	20	--	100
MMECH12	PCC	Machining and Forming Processes	3	1	--	4	60	20	20	--	100
MMECH13	PCC	Mechanical Vibrations	3	1	--	4	60	20	20	--	100
MDE14A	Elective I	Advanced Machine Design	3	--	--	3	60	20	20	--	100
MTE14B		Utilization of Solar Energy									
MTE14C		Advanced I.C. Engines									
MME14D		Additive Manufacturing									
MMECH15A	Elective II	Manufacturing Planning and Control	3	--	--	3	60	20	20	--	100

ME-XX15C		Hydraulic, Pneumatic and Fluidic Control									
MTE15D		Wind Energy									
MME15E		Finite Element Method									
BSH16	HSMC	Communication Skills	2	--	--	2	--	--	25	25	50
MMECH17	PCC	Mechanical Engineering Lab	--	--	3	2	--	--	25	25	50
		Total	**17**	**3**	**3**	**22**	**300**	**100**	**150**	**50**	**600**

Semester-II

<table>
<tr><th rowspan="3">Course Code</th><th rowspan="3">Type of Course</th><th rowspan="3">Name of the Course</th><th colspan="3">Hours/Week</th><th rowspan="3">Credit</th><th colspan="5">Examination Scheme</th></tr>
<tr><th rowspan="2">L</th><th rowspan="2">T</th><th rowspan="2">P</th><th colspan="2">Theory</th><th rowspan="2">CA</th><th rowspan="2">PR/OR</th><th rowspan="2">Total</th></tr>
<tr><th>TH</th><th>Test</th></tr>
<tr><td>MMECH21</td><td>PCC</td><td>Advanced Fluid Mechanics and Heat Transfer</td><td>3</td><td>1</td><td>--</td><td>4</td><td>60</td><td>20</td><td>20</td><td>--</td><td>100</td></tr>
<tr><td>MMECH22</td><td>PCC</td><td>Mechanical Design Analysis</td><td>3</td><td>1</td><td>--</td><td>4</td><td>60</td><td>20</td><td>20</td><td>--</td><td>100</td></tr>
<tr><td>MMECH23A</td><td rowspan="6">Elective III</td><td>Numerical Methods and Computational Techniques</td><td rowspan="6">3</td><td rowspan="6">--</td><td rowspan="6">--</td><td rowspan="6">3</td><td rowspan="6">60</td><td rowspan="6">20</td><td rowspan="6">20</td><td rowspan="6">--</td><td rowspan="6">100</td></tr>
<tr><td>ME-XX23B</td><td>CAD- CAE</td></tr>
<tr><td>MTE23B</td><td>Computational Fluid Dynamics</td></tr>
<tr><td>MTE23C</td><td>Advanced Refrigeration</td></tr>
<tr><td>MTE23D</td><td>Design of Heat Exchangers</td></tr>
<tr><td>MTE23E</td><td>Alternative Fuels for I.C. Engines</td></tr>
<tr><td>MTE24A</td><td rowspan="3">Elective IV</td><td>Steam and Gas Turbines</td><td rowspan="3">3</td><td rowspan="3">--</td><td rowspan="3">--</td><td rowspan="3">3</td><td rowspan="3">60</td><td rowspan="3">20</td><td rowspan="3">20</td><td rowspan="3">--</td><td rowspan="3">100</td></tr>
<tr><td>MME24B</td><td>Surface Engineering</td></tr>
<tr><td>MTE24B</td><td>Cryogenic Engineering</td></tr>
</table>

MMECH24C		Nanotechnology									
MME24F		World Class Manufacturing									
MOE25A	Elective V	Research Methodology	3	--	--	3	60	20	20	--	100
MOE25B		Design of Experiments									
MOE25C		Advanced Optimization Techniques									
MOE25D		Environmental Engineering and Pollution Control									
MOE25E		Soft Computing Techniques									
MOE25F		Manufacturing Automation									
MOE25G		Modeling and Simulation									
MMECH26	PCC	Seminar	--	4	--	2	--	--	50	50	100
MMECH27	PCC	Mini Project	--	--	4	2	--	--	50	50	100
		Total	**15**	**6**	**4**	**21**	**300**	**100**	**200**	**100**	**700**

Semester-III

Course Code	Type of Course	Name of the Course	Hours/Week			Credit	Examination Scheme				
							Theory		CA	PR/OR	Total
			L	T	P		TH	Test			
MMECH31	PCC	Project Management (Self Study Course)	--	--	--	2	--	--	50	50	100
		OR									
MMECH32	PCC	Intellectual Property Rights (Self Study Course)	--	--	--	2	--	--	50	50	100
MMECH33	PCC	Project Stage -I	---	--	--	10	--	--	50	50	100
		Total	---	--	--	**12**	--	--	**100**	**100**	**200**

Semester-IV

Course Code	Type of Course	Name of the Course	Hours/Week			Credit	Examination Scheme				
							Theory		CA	PR/OR	Total
			L	T	P		TH	Test			
MMECH41	PCC	Project Stage -II	---	--	--	20	--	--	100	100	200
		Total	---	--	--	**20**	--	--	**100**	**100**	**200**

Semester -I
Engineering Thermodynamics

MMECH11	Engineering Thermodynamics	PCC	3-1-0	3 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks		Total 100 Marks

Pre-Requisites: Thermodynamics

Course Objectives:

1. To provide the sufficient knowledge of thermodynamics to apply in real engineering problems
2. To familiarize the students about the thermodynamic relations and process and their use to analysis the given thermal application
3. To understand the concept of application of thermodynamics such as refrigeration, Gas cycles etc.

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

CO1	Review the laws of thermodynamics
CO2	Explain the use of Maxwell's relations, Clapeyron equation and apply equations of state for real gases and compare.
CO3	Analysis of second law of thermodynamics for various processes.
CO4	Analyze gas turbine cycles.
CO5	Illustrate the ideal gas, real gas, its deviation with compressibility chart.

Mapping of course outcomes with program outcomes

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

Course Contents:

Unit I

Review of laws of thermodynamics

First law of thermodynamics for a closed system undergoing a cycle and change of state, Limitation of first law of thermodynamics, Second Law of Thermodynamics cycle heat engine, refrigerator and heat pump, Kelvin- Plank and Clausius statements and their equivalence, Reversibility and Irreversibility, Carnot cycle, Carnot theorem, Absolute thermodynamic temperature scale.

Unit II

Entropy

Entropy as a property of system. entropy of pure substance., entropy change in a reversible and irreversible processes, increase of entropy principle, Introduction to Available and unavailable energy: The Entropy Change of Ideal Gases, Reversible Steady-Flow Work, Entropy Change of a System, ΔS system, Mechanisms of Entropy Transfer during Heat and mass transfer, Entropy Generation for closed Systems and Control Volumes

Unit III

Thermodynamic relations

The Ideal-Gas Equation of State ,Other Equations of State:Van der Waals Equation of State ,Beattie-Bridgeman Equation of State,Benedict-Webb-Rubin Equation of State,
Virial Equation of State,Maxwell's equation, joule- kelvin effect,clausius-clapeyron equation.

Unit IV

Properties of Steam:

Dryness fraction, enthalpy, internal energy and entropy, steam table and Mollier chart, first law applied to steam processes.

Vapour Power Cyclesand Gas Power Cycles:

Carnot vapour cycle, Rankine cycle, Ideal reheat, Rankine cycle, Introduction to cogeneration.Air standard assumptions, Otto cycle, Diesel cycle, dual cycle, Stirling cycle, Ericsson cycle, Atkinson cycle, Brayton cycle.

Unit V

Refrigeration Cycles

The Reversed Carnot Cycle, The Ideal Vapor-Compression Refrigeration Cycle,Actual Vapor-Compression Refrigeration Cycle, Selecting the Right Refrigerant, Innovative Vapor-Compression Refrigeration Systems, Multistage Compression Refrigeration Systems, Multipurpose Refrigeration Systems with a Single Compressor Liquefaction of Gases,Gas Refrigeration Cycles, Absorption Refrigeration Systems

Unit VI

Fuels and Combustion

Types of fuels, calorific values of fuel and its determination, combustion equation for hydrocarbon fuel, determination of minimum air required for combustion and excess air supplied conversion of volumetric analysis to mass analysis, fuel gas analysis. Stoichiometric A/F ratio, lean and rich mixture, products of combustion, properties of engine fuels.

Text Books:

1. P. K. Nag, " Engineering Thermodynamics", Tata McGraw Hill, 3rd edition, New Delhi, 2005.
2. Y. A. Cengel, M. A. Boles, "Thermodynamics–An Engineering Approach", Tata McGraw Hill, 5th edition, 2006.

References:

1. G. J. Van Wyle, R. E. Sonntag, "Fundamental of Thermodynamics", John Wiley & Sons, 5th edition, 1998.
2. M. J. Moran, H. N. Shaprio, "Fundamentals of Engineering Thermodynamics", John Wiley and Sons,4th edition, 2004.

Machining and Forming Processes

MMECH12	Machining and Forming Processes	PCC	3-1-0	4 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

Course Objectives:

1. To provide the sufficient knowledge of machining and forming processes to apply in real engineering problems
2. To familiarize the students about the fundamental principles of machining and forming
3. To understand the importance of machining and forming process applied to industrial applications

Pre-Requisites:

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

CO1	Classify conventional and non-conventional machining processes.
CO2	Understand mechanism of metal cutting, introduction to tool life,cutting fluids.
CO3	Describe the mechanism and mechanics of grinding processes,various non-conventional machining processes.
CO4	Rolling, extrusion and wire drawing processes.
CO5	Forging in plain stain, calculations of forging loads in Closed die forging ,residual stresses in forgings, Forging defects
CO6	Sheet metal working processes.

Mapping of course outcomes with program outcomes

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2		1			2						
CO2	3		1			2						
CO3	2			1								
CO4	2			1		1						
CO5	2	2		1		2						
CO6	2	2		1		2						

Course Contents

Unit I

Machine Tools and machining operation: Introduction, generating motions of machine tools, machines using single point tools, machines using multipoint tools, machines using abrasive wheels, summary of machine tool characteristics and machining equations.

Unit II

Mechanics of Metal Cutting: Introduction, terms and definitions, chip formation, forces acting on the cutting tool chip thickness, friction in metal cutting.

Tool life and tool Wear: Introduction, Cutting Fluid and Surface roughness: application of cutting fluids

Unit III

Grinding: Introduction, grinding wheel, effect of grinding conditions on wheel behavior, determination of the density of active grains.

Nonconventional Machining Processes: Introduction, range of nonconventional machining processes, ultrasonic machining, water-jet machining, abrasive-jet machining, chemical machining, electrochemical machining.

Unit IV

Rolling: Forces and Geometrical Relationships in rolling, Analysis of Rolling load and variables, Problems and Defects in rolled products, Theories of cold and hot rolling, Rolling mill control. Extrusion: Analysis of extrusion,Deformation, Lubrication and defects in extrusion, production of seam less pipe and tubing, drawing of rods, wires and tubes: Analysis of wire and tube drawing, residual stresses in rod, wire and tubes. Sheet metal forming: Forming limitcriteria and Defects in formed components.

Unit V

Forging in plain stain, calculations of forging loads in Closed die forging, residual stresses in forgings, Forging defects

Unit VI

Basic applications: shearing processes like blanking, piercing, and punching.

Drawing processes like shallow and deep drawing of cylindrical and rectangular bodies forming and bending including estimation and control of spring back.

TEXTS/REFERENCES:

1. G. Boothroyd and W.A. Knight, *Fundamentals of Maching and Machine Tools*, 2nd Edition, Mercell Dekker, New York, 1989.
2. A. Ghosh and A.K. Mullick, *Manufacturing Science*, Affiliated East-West Press, 1985.
3. J. McGeough, *Advanced Methods of Machining*, Chapman and Hall, London, 1988.

Mechanical Vibrations

MMECH13	Mechanical Vibrations	PCC	3-1-0	4 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

Course Objectives:

1. To provide the sufficient knowledge of mechanical vibrations to apply in real engineering problems
2. To familiarize the students about the fundamental principles of mechanical vibrations
3. To understand the importance of vibrations in the background of bear and tear of the machine components, noise reductions and conditioning monitoring

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

CO1	To develop in our students the ability to engage themselves to solve vibration problems.
CO2	To be creative problem solvers whilst dealing with machinery involving periodic phenomena
CO3	To integrate empirical analysis and add to the world of field expertise where possible
CO4	To adapt to recent advances in knowledge

Mapping of course outcomes with program outcomes

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

Course Contents

Unit I

(A) **Multi Degree Freedom System:**

Free Vibration equation of motion. Influence Coefficient i) Stiffness Coeff. (ii) Flexibility Coefficient. Generalized coordinates, and Coordinate couplings. Lagrange's Equations Matrix Method Eigen Values Eigen Vector problems. Model Analysis.Forced Vibrations of undamped system and modal analysis.

(B)**Multi Degree System Numerical Methods:**

(i)Rayleigh`s Method, (ii)Rayleigh-Ritz Method (iii) Holzer`s Method (iv)Methods of Matrix iterations (v) Transfer Matrix Method, Impulse response and frequency response functions.

Unit II

Continuous System:

Vibrations of String, Bars, Shaftsand beams, free and forced vibration of continuous systems.

Transientvibrations:

Response of a single degreeoffreedomsystemtostepandanyarbitraryexcitation, convolution(Duhamel's)integral impulse response functions.

Unit III

Vibration Control:

Balancingofrotatingmachine,In-situ balancing f rotors, controlof naturalfrequency introductionof damping,vibrationisolation&vibrationabsorbers.

Vibration Measurement:-

FFTanalyzer,vibrationexciters,Signalsanalysis. Timedomain&Frequencydomainanalysis of signals.Experimentalmodalanalysis,MachineConditioningandMonitoring,Fault diagnosis.ExampleofVibrationtests- Industrial casestudies.

Unit IV

Random Vibrations:

Expectedvaluesauto andcross correlationfunction,Spectral density, response of linearsystems, analysisof narrow band systems.

Unit V

Non-LinearVibrations:

Systems with non-linearelasticproperties, free vibrations of systemwith non-linearelasticity and damping,phase-planetechnique,Duffing'sequation,Jump phenomenon,Limitcycle, Perturbationmethod.

Unit VI

Noiseand Its Measurement:

Soundwaves,governingequationitspropagation**,**Fundamentals ofNoise, Decibel, SoundIntensity,Sound fields, reflectionabsorptionandtransmission. Noisemeasurement,Soundmeter, allowedexposure levelsandtimelimitbyB.I.S.,OctaveBand analysisofsound, FundamentalsofNoisecontrol, sourcecontrol,pathcontrol,enclosures, noise absorbers, noise controlatreceiver.

TEXTS / REFERENCES:

1. Theory of Vibrations with Applications: W T Thomson, Pearson Publications.
2. Mechanical Vibrations: S S Rao Pearson Publications.
3. Fundamentals of Vibration: Leonard Meirovitch, McGraw Hill International Edison.
4. Principles of Vibration Control:Asok Kumar Mallik, Affiliated East- West Press.
5. Mechanical Vibrations: A H Church, John Wiley & Sons Inc.
6. Mechanical Vibrations: J P Den Hartog, McGraw Hill.
7. Mechanical Vibration Analysis:Srinivasan, McGraw Hill.
8. Mechanical Vibrations: G K Groover.
9. Vibration and Noise for Engineers: KewalPujara ,Dhanpat Rai & co.
10. C.Sujatha "Vibration & Acoustics" TMH New Delhi.

Advanced Machine Design

MDE14A	Advanced Machine Design	Elective I	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

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

CO1	To analyze variance, factorial design and regression and understand reliabilitytheory, design and analysis of reliability.
CO2	Students will have the ability to analyze behavior of mechanical elements under fatigue and creep
CO3	.to study optimization and its methods.
CO4	To study composite materials and its characteristics.
CO5	To design mechanical components for various materials and process.

Mapping of course outcomes with program outcomes

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1		1			1						
CO2	1											
CO3	1		1			1						
CO4		1			1							
CO5	1		1			2						

Course Contents

Unit I
Engineering statistics:-
Analysis of variance (ANOVA), factorial design and regression analysis. Reliability theory, design for reliability, Hazard analysis, fault free analysis

Unit II
Fatigue and Creep:-
Introduction, Fatigue strength, factors affecting fatigue behavior, Influence of super imposed static stress, Cumulative fatigue damage, fatigue under complex stresses, Fatigue strength after over stresses, True stress and true strength, mechanism of creep of material at high temperature, Exponential creep law, hyperbolic sine creep law, stress relaxation, bending etc.

Unit III
Optimization: -Introduction, multivariable search methods, linear & geometric programming, structural and shape optimization and simplex method

Unit IV
Composite materials:-
Composite materials and structures, classical lamination theory, elastic stress analysis of composite material, Fatigue strength improvement techniques, stresses , stress concentration

around cutouts in composite laminates, stability of composite laminate plates and shells, Hybrid materials, applications.

Unit V

Design forMaterialsand Process: Designforbrittlefracture,Designforfatiguefailure, Design fordifferentmachiningprocess, assembly&safety etc.

Unit VI

Design of Mechanical components: -

a) Gear Design: - Involute gears, tooth thickness, interference, undercutting, rackshift etc. Profile modification, S and So spur, helical gears etc.

b) Spring Design:- Vibration and surging of helical springs, helical springs for maximum space efficiency , analysis of Belleville springs, ring spring, volute spring & rubber springs. Design for spring suspension.

c) Design of Miscellaneous components (to be detailed) Cam shaft with valve opening mechanism, piston, cylinder, connecting rod etc.

Texts / References:

1. J.F.Blackburn, G.Rechthof, J.L. Shearer, *Fluid Power Control*, MIT.
2. B.W.Anderson,*The Analysis and Design of Pneumatic Systems*, Wiley.
3. K.Foster, G.Parker, *Fluidic Components and Circuits*, Wiley.
4. A.B.Goodwin, *Fluid Power Systems*, Macmillan.

Utilization of Solar Energy

MTE14B	Utilization of Solar Energy	Elective I	3-0-0	2 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

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

CO1	Describe measurement of direct, diffuse and global solar radiations falling on horizontal and inclined surfaces, Basic earth sun angles, Beam and diffuse radiations, Radiation on titled surfaces.
CO2	Analyze the performance by conducting research on flat plate collector, air heater and concentrating type collector.
CO3	Understand test procedures and apply these while testing different types of collectors.
CO4	Demonstrate and Design various types of thermal energy storage systems.
CO5	Analyze payback period and annual solar savings due to replacement of conventional systems
CO6	Demonstrate the importance of solar energy effectively to increase awareness of it in society.

Mapping of course outcomes with program outcomes

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1			1								

CO2				1								
CO3				1								
CO4									1			
CO5						2						
CO6			2		1							

Course Contents

Unit I:
Solar Radiation Analysis: Solar constant, Basic earth sun angles, Beam and diffuse radiations, Radiation on titled surfaces (estimation), Measurement of solar radiation (calibration of equipment)

Unit II:
Heat Transfer for Solar Energy Utilization: Basic models of heat transfer, Radiation characteristics of opaque materials and partially transparent media, Heat transfer analysis for flat plate collectors (numerical problems)
Flat Plate Collectors: Physical principles of conversion of solar radiation into heat, Thermal losses and efficiency of FPC, Practical considerations for flat plate collectors, Applications of FPC – Water heating and Drying

Unit III:
Focusing Type Collectors: Orientation and sun tracking systems, Types of concentrating collectors – Cylindrical parabolic collector, Compound parabolic collector, Thermal performance of focusing collectors, Testing of solar collectors.

Unit IV:
Solar cooking, Solar desalination, Solar ponds and Solar space heating Solar Industrial process heating and Solar power generation.

Unit V:
Solar Green Houses, Solar thermo mechanical power, Solar refrigeration & air conditioning and Solar High Temperature Applications

Unit VI:
Energy Storage for Solar Energy Utilization: Importance of storage systems, Different types of thermal storage systems, Alternate storage methods

Texts / Reference Books:

1. John A Duffie& William A Beckman : “Solar Energy Thermal processes” – Wiley Inter science publication
2. H P Garg & J Prakash “Solar Energy – Fundamentals and Applications: - Wiley Inter science
3. G D Rai “Solar Energy Utilization” – Khanna publishers
4. S P Sukhatme “Solar Energy – Principles of thermal Collection & Storage” – Tata McGraw Hill Publishing company ltd., New Delhi

Advanced I.C. Engines

MTE14C	Advanced I.C. Engines	Elective I	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

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

CO1	Demonstrate energy management principles, identify need, organizing it. carry out energy auditing.
CO2	Conduct economic analysis of any industry or power plant, obtain conclusion and suggest it to industry.
CO3	Interpret financial appraisal methods, and thermodynamic analysis, and estimate financial budget of visited industry.

Mapping of course outcomes with program outcomes

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2										
CO2			1	1		1		2				
CO3				1	1		1	2				

Course Contents:

Unit I:
Introduction – Historical Review – Engine Types – Design and operating Parameters.
Cycle Analysis: Thermo-chemistry of Fuel – Air mixtures, properties – Ideal Models of Engine cycles– Real Engine cycles -differences and Factors responsible for – Computer Modeling.

Unit II:
Gas Exchange Processes: Volumetric Efficiency – Flow through portsSupercharging and Turbo charging.
Charge Motion: Mean velocity and Turbulent characteristics – Swirl, Squish – Pre-chamber Engine flows.

Unit III:
Engine Combustion in S.I. Engines: Combustion and Speed – Cyclic VariationsIgnition – Abnormal combustion Fuel factors, MPFI, SI engine testing.
Combustion in CI engines: Essential Features – Types off Cycle. Pr. Data – FuelSpray Behavior – Ignition Delay – Mixing Formation and control, Common rail fuel injection system.

Unit IV:
Pollutant Formation and Control: Nature and extent of problems –Nitrogen Oxides,Carbon monoxide, unburnt Hydrocarbon and particulate – Emissions
Measurement – Exhaust Gas Treatment, Catalytic converter, SCR, Particulate Traps, Lean,

NOx, Catalysts.

Unit V:
Engine Heat Transfer: Importance of heat transfer, heat transfer and engine energybalance,Convective heat transfer, radiation heat transfer, Engine operating characteristics.
Fuel supply systems for S.I. and C.I engines to use gaseous fuels like LPG, CNG and Hydrogen.

Unit VI:
Modern Trends in IC Engines: Lean Burning and Adiabatic concepts, Rotary Engines, Modification in I.C engines to suit Bio – fuels, HCCI and GDI concepts.

Text/ References:

1. I.C. Engines / V.Ganesan/TMH
2. I.C. Engines Fundamentals/Heywood/TMH
3. I.C. Engines/G.K. Pathak & DK Chevan/ Standerd Publications
4. I.C. Engines /RK Rajput/Laxmi Publications
5. Computer Simulation of C.I. Engine Process/ V.Ganesan/University Press
6. Fundamentals of IC Engines/HN Gupta/PHI/2nd edition
7. I.C. Engines/Fergnson/Wiley
8. The I.C. Engine in theory and Practice Vol.I / Teylor / IT Prof.AndVol.II

Additive Manufacturing

MME14D	Additive Manufacturing	Elective I	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

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

CO1	Understand the importance of Additive Manufacturing
CO2	Classify the different AM processes
CO3	Design for AM processes
CO4	Understand the applications of AM
CO5	Apply the AM Processes bio-medical applications

Mapping of course outcomes with program outcomes

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

Course Contents

Unit I:
Introduction
Overview - Historical Development - Need – Classification - Additive Manufacturing Technology in product development – Materials for Additive Manufacturing Technology – Traditional v/s Additive Manufacturing – Tooling – Benefits and Applications.

Unit II:
Geometric Model & Reverse Engineering
Basic Concept – Digitization Techniques – Model Reconstruction – Data Processing for Additive Manufacturing Technology, CAD model preparation – Interface Formats - Part Orientation and support generation – Model Slicing – Tool path generation – Software for Additive Manufacturing Technology: RP software.

Unit III:
Liquid Based and Solid Based Additive Manufacturing Systems
Classification – Liquid based system – Stereolithography Apparatus (SLA) – Principle, process, advantages and applications – Solid based system – Fused Deposition Modeling – Principle, process, advantages and applications, Laminated Object Manufacturing.

Unit IV:
Powder Based Additive Manufacturing Systems
Selective Laser Sintering(SLS) – Principle, process, advantages and applications – Three Dimensional Printing – Principle, process, advantages and applications – Laser Engineered Net Shaping (LENS), Electron Beam Melting – Shape deposition manufacturing, Laser deposition, Lamination, Electro-optical sintering.

Unit V:
Rapid Casting and Segmental Object Manufacturing, Visible Slicing Implementation
Rapid casting using wax patterns, acrylic patterns, dense polystyrene patterns – Expanded polystyrene process – Rapid manufacturing of metallic objects.

Unit VI:
Medical and Bio-Additive Manufacturing
Customized implants and prosthesis, Design and production, Bio-Additive Manufacturing – Computer Aided Tissue Engineering (CATE) – Case Studies.

Text Books:

1. Chua C.K., Leong K.F. and Lim C.S., "Rapid prototyping: Principles and applications", Third Edition, World Scientific Publishers, 2010.
2. Gebhardt A., "Rapid Prototyping", Hanser Gardener Publications, 2003.

References:

1. Liou L.W. and Liou F.W., "Rapid Prototyping and Engineering applications: A tool box for prototype development", CRC Press, 2007.

Manufacturing Planning and Control

MMECH15A	Manufacturing Planning And Control	Elective II	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks		Total 100 Marks

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

CO1	Apply the systems concept for the design of production and service systems.
CO2	Make forecasts in the manufacturing and service sectors using selected quantitative and qualitative techniques.
CO3	Apply the principles and techniques for planning and control of the production and service systems to optimize/make best use of resources.
CO4	Understand the importance and function of inventory and to be able to apply selected techniques for its control and management under dependent and independent demand circumstances.
CO5	Understand the lot sizing and production scheduling.
CO6	Study about quality planning, cost planning and control.

Mapping of course outcomes with program outcomes

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2									1		
CO2	2	1		1	2		1	2				
CO3	2				2		1	2				
CO4	2				2		2	2				
CO5	2			1	1	1	1	2				
CO6	2				1	1	1	3				

Course Contents

Unit I:
Overview of manufacturing systems and various issues of interest: assembly line, repetitive batch manufacturing.

Unit II:
Cellular manufacturing, FMS, JIT, CIM, preplanning: forecasting, economic analysis, aggregate planning, capacity planning, inventory planning.

Unit III:
Decision making in design of manufacturing systems: group technology, line balancing, plant layout.

Unit IV:
Operations planning: MRP, MRP II, hierarchical planning systems, JIT systems.

Unit V:
FMS Operation and control: lot sizing decisions, production scheduling, line of balance.

Unit VI:
Quality planning and control, cost planning and control, Simulation analysis of manufacturing systems, case studies.

Texts / References:

1. D.D.Bedworth and J.E Bailey, *Integrated Production Control, System-management, Analysis and Design*, John Wiley, 1983.
2. E.A.Elsayed and T.O.Boucher , *Analysis and Control of Production Systems*, Prentice Hall, 1985.
3. J. R.King ,*Production Planning and Control*, Pergamon Press, Oxford, 1975.
4. P.F.Bestwick and K.Lockyer, *Quantitative Production Management*, Pitman Publications, 1982.
5. A.C.Hax and D.Candea, *Production and Inventory Management*, Prentice-Hall, 1984
6. M.G.Korgaokar, *JIT Manufacturing*, Macmillan, 1992.

Hydraulic, Pneumatic and Fluidic Control

ME-XX15C	Hydraulic, Pneumatic and Fluidic Control	Elective II	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

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

CO1	Understand the type of control system and their utility
CO2	Describe the hydraulic power generation
CO3	Design pneumatic and hydraulic circuits for a given application
CO4	Discuss steady state operating forces, transient forces and valve instability
CO5	Design of pure fluid digital elements, Lumped and distributed parameter fluid systems

Mapping of course outcomes with program outcomes

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

Course Contents

Unit I:
Introduction to control system, types of control system and their utility.

Unit II:
Hydraulic power generation and transmission, valve control pressure flow relationship and constructions.

Unit III:
Steady state operating forces, transient forces and valve instability.

Unit IV:
Circuit design, pneumatic valves, hydraulic and pneumatic drives, introduction to fluidic devices and sensors.

Unit V:
Lumped and distributed parameter fluid systems, fluid mechanics of jets, wall attachment and vortex devices.

Unit VI:
Pure fluidic analog amplifiers, analog signal control techniques, design of pure fluid digital elements.

Texts / References:

1. J.F.Blackburn, G.Rechthof, J.L. Shearer, *Fluid Power Control*, MIT.
2. B.W.Anderson,*The Analysis and Design of Pneumatic Systems*, Wiley.
3. K.Foster, G.Parker, *Fluidic Components and Circuits*, Wiley.
4. A.B.Goodwin, *Fluid Power Systems*, Macmillan.

Wind Energy

MTE15D	Wind Energy	Elective II	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks		Total 100 Marks

Course Objectives: Objectives of this course are

1. To understand history of wind energy and its scope in future.
2. To get practical knowledge about use various wind energy measurement indicators, anemometers
3. To calculate various parameters of wind turbine**.**

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

CO1	Identify and describe history of wind energy and its scope in future.
CO2	survey and analyze through a literature review world distribution of wind, Weibull

	statistic, variation in wind energy etc.,
CO3	Conduct an experiment to use various wind energy measurement indicators, anemometers, and apply it to analyze and check data obtained from surveys.
CO4	Demonstrate and calculate performance parameters wind energy turbine.
CO5	Illustrate various electrical systems used in wind energy power plant.
CO6	Examine and justify economics of wind system.

Mapping of course outcomes with program outcomes

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	2								
CO2	1		2		1	1					1	
CO3	2	1	1									
CO4	1			2	1	1						
CO5	1	1										
CO6	1	1			1			1				

Course Contents

Unit I:
Introduction: Historical uses of wind, History of wind electric generations.

Unit II:
Wind Characteristics: Metrology of wind, World distribution of wind, Atmospheric stability, Wind speed variation with height, Wind speed statistics, Weibull statistics, Weibull parameters, Rayleigh and normal distribution.
Wind Measurements: Biological indicators, Rotational anemometers, other anemometers, Wind direction.

Unit III:
Wind Turbine Power, Energy and Torque: Power output from an ideal turbine, Aerodynamics, Power output from practical turbines, Transmission and generation efficiency, Energy production and capacity factor, Torque at constant speeds, Drive train oscillations, Turbine shaft power and torque at variable speeds.

Unit IV:
Wind Turbine Connected to the Electrical Network: Methods of generating synchronous power, AC circuits, the synchronous generator, per unit calculations, the induction machine, Motor starting, Capacity credit features of electrical network.
Wind turbines with Asynchronous Electric Generators: Asynchronous systems, DC shunt generator with battery load, Per unit calculation, Self excitation of the induction generators, Single phase operation the induction generator, Field modulated generators, Roesel generator.

Unit V:
Asynchronous Load: Piston water pumps, Centrifugal pumps, Paddle wheel heaters, Batteries, Hydrogen economy, and Electrolysis cells.

Unit VI:
Economics of Wind Systems: Capital costs, Economic concepts, Revenues requirements, Value of wind generated electricity

Text/Reference Books:
1. Garg L Johnson: “Wind Energy Systems” Prentice Hall. Inc, New Jersey – 1985
2. Desire Le Gouriers: “Wind Power Plants: Theory and Design” Pergamon Press – 1982

Finite Element Method

MME15E	Finite Element Method	Elective II	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

Pre-Requisites: None
Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the basics principle of FE method
CO2	Identify mathematical model for solution of common problems
CO3	Solve structural, thermal problem using FE in 1D Case
CO4	Derive element stiffness matrix by different methods
CO5	Understand the formulation for 2D and 3D case
CO6	Recognize need for and engage in lifelong learning

Mapping of course outcomes with program outcomes

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

Course Contents:

Unit I:
- 1-D Problems: Introduction to structural analysis and FEM, Introduction to approximate solutions and FEM, summary of linear elastic mechanics.

Unit II:
- 1-D Problems: Principles of linear elastic mechanics, principles of virtual displacements and minimum potential energy, Rayleigh Ritz method, exact v/s approximate solution, beam elements.

Unit III:
- 2-D Problems: Plane stress and plane strain conditions, triangular elements, constant strain triangle, linear strain triangle, Boundary conditions, body forces and stress recovery, quadrilateral elements.

Unit IV:

- 2-D Problems: Lagrange and Serendipity shape functions, isoparametric formulation, numerical integration, modeling with isoparametric elements, requirements for convergence, patch test, nonconforming elements, reduced integration.

Unit V:

- 3-D Problems: Axisymmetric solids, governing equations, axisymmetric elements and their applications, mixed formulations, bending of flat plates (Kirchhoff Theory), continuity requirements and boundary conditions.

Unit VI:

- 3-D Problems: Discrete Kirchhoff's elements, thick plate elements, plate bending applications, shells as assemblage of flat plates, finite element formulation for dynamic problems, mass properties, introduction to elastic stability for frames and plates.

Texts / References:

1. R. D. Cook, Concepts and Applications of Finite Element Analysis; John Wiley and Sons, second edition, 1981.
2. C.S. Krishnamurti, Finite element method; Tata Mc-Graw Hill Publication.
3. K.J. Bathe, Finite Element Method and Procedures; Prentice hall, 1996.
4. Tirupathi, R., and Chandrupatla, Finite Elements in Engineering; PHI Publication, New Delhi.
5. Bruce Irons and Soharab Ahmed, Techniques of Finite Elements; John Wiley and Sons, New York.
6. K.J. Bathe, Finite Element Method; Prentice Hall, 1987.
7. O.P., Goptha, Finite and Boundary Element Methods in Engineering; Oxford and IBH.

Communication Skills

BSH16	Communication Skills	HSSC	2-0-0	2 Credits

Pre-Requisites: None
Course Outcomes: At the end of the course, the student will be able to:

CO1	
CO2	
CO3	
CO4	
CO5	
CO6	

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												

CO3												
CO4												
CO5												
CO6												

Course Contents:

UnitI:
Introduction to communication, Necessityofcommunication skills, Features ofgood communication, Speakingskills, Feedback&questioningtechnique, Objectivityin argument

Unit II:
Verbaland Non-verbalCommunication, Useand importanceof non-verbalcommunication while usinga language, Studyofdifferentpictorialexpressionsofnon-verbalcommunicationand theiranalysis

UnitIII:
Academic writing, Different typesofacademic writing, WritingAssignments and Research Papers, Writingdissertations andprojectreports

UnitIV:
Presentation Skills:Designingan effective Presentation, Contents,appearance,themes in a presentation, Tone and Language in a presentation, Roleand Importance ofdifferenttoolsfor effective presentation

UnitV:
Motivation/Inspiration:Abilitytoshape anddirectworking methods accordingto self-definedcriteria Abilitytothinkforoneself,Applyoneselfto ataskindependentlywith self-motivation,Motivation techniques:Motivationtechniques based on needs andfield situations

UnitVI:
SelfManagement,SelfEvaluation,Selfdiscipline, Selfcriticism, Recognitionofone'sown limits and deficiencies,dependency, etc.
SelfAwareness, Identifyingone's strengths andweaknesses, Planningand Goalsetting, Managingself- emotions, ego, pride, Leadership andTeamDynamics.

Texts/ ReferenceBooks:

1. Mitra, Barun, *PersonalityDevelopment and SoftSkills*, Oxford UniversityPress, 2016
2. Ramesh, Gopalswamy, *TheAceof Soft Skills: Attitude, Communication and Etiquette forSuccess*, Pearson Education, 2013
3. Covey, Stephen R.,*Seven Habits of HighlyEffectivePeople: Powerful Lessons in Personal Change*
4. RosenbergMarshallB.,*Nonviolent Communication: A Language of Life*

Mechanical Engineering Lab

MMECH17	Mechanical Engineering Lab	PCC	0-0-3	2 Credits
Exam Scheme				
Continuous Assessment: 25 Marks	PR/ OR: 25 Marks		Total: 50 Marks	

Course Objectives:

1. To apply the theoretical concepts and enhance understanding of the engineering concepts
2. To familiarize the students about the measurements and error calculations during experiments
3. To understand the design of experiments and report writing

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

CO1	Conduct test on hydraulic turbines like Pelton wheel, Francis turbine, IC Engines, Refrigeration and air conditioning test units, solar system etc. to study their performance and analyze the result.
CO2	Draw and analyze performance curves of these machines/systems.
CO3	Analyze the results obtained from the tests.

Mapping of course outcomes with program outcomes

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1		1			2					2	
CO2	1			1								
CO3	2					1						

Experiments on the following set-ups (Any Four):

1. Heat Transfer Enhancement
2. Computerised Single Cylinder Diesel Engine using Alternative Fuel
3. Air Conditioning Test-rig
4. Centrifugal/Gear Pump at Variable speed
5. Unsteady State Heat Transfer
6. Blower Test-rig
7. CADmodeling of any two machine components using Catia/Pro-E/Solidedge/ any suitable modelling software
8. Mini project: On FEM analysis of any two machine members by using reputed commercial software for stress distribution, stress concentration and report writing on results of analysis. Using Ansys/Nastran/ Hypermesh/ LS-DYNA / any suitable analysis software.

Study include performance evaluation, calibration of measuring instrument/s and error analysis, innovative experiment/s

Semester II

Advanced Fluid Mechanics and Heat Transfer

MMECH21	Advanced Fluid Mechanics and Heat Transfer	PCC	3-1-0	4 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

Course Objectives:

1. To provide the technical understanding the concepts of heat transfer and fluid mechanics
2. To familiarize the students about the importance of heat transfer and fluid mechanics processes apply to industrial applications
3. To understand the heat transfer and fluid mechanics applications apply to other domain of thermal engineering in general

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

CO1	Analyze steady state and transient heat conduction problems of real life Thermal systems
CO2	Analyze extended surface heat transfer problems and problems of phase change heat transfer like boiling and condensation
CO3	Apply the basic principles of classical heat transfer in real engineering application
CO4	Analyze the analytical and numerical solutions for heat transfer problem.
CO5	Understand the basic concepts of turbulence and their impact on heat transfer
CO6	Analyze convective heat transfer in common geometries like tube, plate, cylinder

Mapping of course outcomes with program outcomes

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2											
CO2	1			1		1						
CO3	1		2									
CO4	1	1		2								
CO5	1											
CO6	1			1								

Course Contents

Unit I:
Concept of continuum and definition of a fluid. Body and surface forces, stress tensor, Scalar and vector fields, Eulerian and Lagrangian approach.

Unit II:
Motion of fluid element - translation, rotation and vorticity; strain rate tensor, continuity equation, stream function and velocity potential. Transport theorems, constitutive equations,

Unit III:
Derivation of Navier Stokes equations for compressible flow. flow over a flat pate, cylinders and spherical bodies, theory of hydrodynamic lubrication,
Boundary layer: derivation, exact solutions, Non dimensionalizationof Boundary layer equation, Blasius (similarity solution),
Computational fluid dynamics: Introduction, fundamentals of numerical analysis of partial differential equations (PDE).

Unit IV:
Brief introduction to different modes of heat transfer: conduction: general heat conduction equation-initial and boundary conditions.
Finite difference methods for conduction: id & 2d steady state and simple transient heat conduction problems-implicit and explicit methods.

Unit V:
Transient heat conduction: lumped system analysis, Heisler charts, semi-infinite solid, use of shape factors in conduction, 2d transient heat conduction, product solutions.

Unit VI:
Convection and Boiling: Flow over a flat plate: Application of empirical relations to variation geometries for laminar and turbulent flows. hydrodynamic &thermal entry

lengths;use of empirical correlations. Approximate analysis on laminar free convective heat transfer, combined free and forced convection. Boiling curve, correlations, assumptions & correlations of film condensation for different geometries

Texts / References:

1. F.M.White ,K.Muralidhar and Bishwas, Advance Engineering fluid mechanics, Alpha science International limited
2. Fox and McDonald, *Introduction to Fluid Mechanics*, J.H. Wiley and Sons.
3. YunusA.Cengal, *Heat and Mass Transfer* – A practical Approach, 3rd edition, Tata McGraw - Hill, 2007.
4. S. P.Sukhatme, *A Textbook on Heat Transfer*
5. Ozisik. M.N., *Heat Transfer – A Basic Approach*, McGraw-Hill Co., 1985

Mechanical Design Analysis

MMECH22	Mechanical Design Analysis	PCC	3-1-0	4 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks		Total 100 Marks

Course Objectives:

1. To provide the technical understanding the concepts of Mechanical design in the background of real engineering problems
2. To familiarize the students about the importance of Mechanical design apply to industrial applications
3. To understand the Analysis of design

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

CO1	To analyze variance, factorial design and regression and understand reliability theory, design and analysis of reliability.
CO2	Students will have the ability to analyze behavior of mechanical elements under fatigue and creep
CO3	to study optimization and its methods.
CO4	To study composite materials and and its characteristics.
CO5	To design mechanical components for various materials and process

Mapping of course outcomes with program outcomes

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

Course Contents:

Unit I:

Introduction: Failure Analysis, Limit design, Fundamentals of fracture mechanics. Fatigue designing for finite life, contact stresses and surface failures, oil films and their effects

Unit II:

Impact: Energy methods, longitudinal stress waves in elastic media impact on beams, torsional impact on shafts and longitudinal impacts on helical springs.

Unit III:

Thermal properties and stresses: Effect of short term and long term properties of materials on design, creep and stress relaxation. Elementary analysis of thermal stresses, thermal fatigue

Unit IV:

Designwith compositematerials:Polymersand F.R.P. asmaterialsform Mechanical components. Reliability based design:Definitionnormal exponential landWeibulldistributionssystem reliability.Reliabilitybased on strength.

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Unit V:

Optimum design: Basis concepts, introduction to various techniques of optimization, optimum design of simple mechanical components.

Unit VI:

Analysis and design of power transmission systems and elements such as: Spur, helical, bevel and worm gear drives, speed reducers and gear boxes, epicyclic gear drives, selection of ball and roller bearings.

TEXTS / REFERENCES:

1. ArthurH.Burr&JohjB.Cheatham,"MechanicalAnalysisandDesign",Prentic-Hallof India (1997).
2. KennethEdwards&RobertB. Makee,"FundamentalsofMechanicalComponentDesign", McGrawHillInternational ed. 1991.
3. Joseph EdwardShigley&CharlesR. Mischke, "MechanicalEngineeringDesign", Mc. Graw Hill (1989).
4. M. F. Spotts"MechanicalDesignAnalysis",PrenticeHall.
5. AaronD.Deutschmanetal,"MachineDesign"CollierMacmillanPublishersInternationaledition.

Numerical Methods and Computational Techniques

MMECH23A	Numerical Methods and Computational Techniques	Elective III	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

Course Outcomes:

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

CO1	Describe the concept of error
CO2	Illustrate the concept of various Numerical Techniques
CO3	Evaluate the given Engineering problem using the suitable Numerical Technique
CO4	Develop the computer programming based on the Numerical Techniques

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2											
CO2	1	2				1						
CO3	1	3		1		2						
CO4	1	2		3	2	1				2		2

Course Contents

Unit I:
Newton forward, backward; central difference, Gauss, Stirling, Bessel's numerical differentiation and integration.

Unit II:
Solution of numerical algebraic, transcendental and simultaneous linear equations.

Unit III:
Numerical solution of ordinary differential equation (ODE) and partial differential equation(PDE), computational Techniques.

Unit IV:
Types of Computer: Digital, analog and hybrid, organization of a digital computer system-CPU, memory, I/O devices, representation of numbers-integer and floating point arithmetic, round off errors and their propagation operations planning: MRP, MRP II, hierarchical planning systems, JIT systems.

Unit V:
Introduction to Computer Languages: Machine language, assembly language., higher level languages, compilers and interpreters, problem solving using computers algorithm, flow chart. FORTRAN programming constants and variables, arithmetic expression, I/O statements, specification statement, control statements, subscripted variables, logical expression function and subroutines, examples of programming should include numerical as

well as non-numeric applications, matrix operations, searching. sorting (bubble). FMS Operation and Control: lot sizing decisions, production scheduling, line of balance.

Unit VI:
Iterative Techniques for Solution of Equations: Simple iteration scheme, Newton-Raphson method, secant method, their rates of convergence, order of errors, roots of polynomial equation, Gaussian elimination, Gauss-Siedel iteration; matrix inversion by Gaussian method, computation of determinant; polynomial approximation.
Quality planning and control, cost planning and control, Simulation analysis of manufacturing systems, Case studies.

Texts / References:

1. V. Rajaram,*Computer Oriented Numerical Methods*, Prentice Hall of India. (Delhi).
2. S.D. Conte, *Elementary Numerical Analysis*.
3. S.S. Shastry, *Introductory Methods of Numerical Analysis*.
4. M.G. Salve, *Numerical Methods in Engineering*.
5. R.T.Fennes ,*Computing for Engineering*.

CAD-CAE

ME-XX23B	CAD-CAE	Elective III	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

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

CO1	Demonstrate - Polynomial and spline interpolation, Bezier curves, B-splinesto surfaces representation, patches and composite surfaces.
CO2	Design and create Solid model assembly of thermal and fluid engineering system in CAD software.
CO3	Analyze simple Engineering problem by selecting appropriate Mesh generation.
CO4	Modeling and Meshing of Thermal and Fluid Flow equipment in CAD.
CO5	Simulate and demonstrate Thermal and Fluid systems by using ANSYS, EES, MATLAB etc.
CO6	Understand and simulate computer aided manufacturing.

Mapping of course outcomes with program outcomes

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2											
CO2		1		1	1							
CO3		2		1								
CO4	1	1		1								

CO5	1	1		3									
CO6	1	1											

Course Contents

Unit I:
Overview of CAD Applications, Curves - Polynomial and spline interpolation, Bezier curves, B-splines, Introduction to surfaces representation, patches and composite surfaces [~4 hours]
Solid Modeling: Representation of Solids, Topology, Wireframe, Boundary representation (B-Rep), CSG, Solid modeling operations.

Unit II:
Computer Graphics: Mathematical principles for 2D and 3D visualization, Matrix transformations, Modeling, viewing, projection and rendering, OpenGL graphics library, CAD data formats and exchange.
Meshing – Mesh topology, Data structures, Introduction to Mesh generation algorithms, Surface meshes, Element types and quality criteria.

Unit III:
Hands-on lab sessions: Modeling and Meshing of Thermal and Fluid Flow equipment.

Unit IV:
Computer Aided Engineering: Lab simulations for Thermal and Heat Transfer, Computational Fluid Dynamics: Lab simulations for Fluid Flow.

Unit V:
Computer Aided Engineering: Multiphysics lab simulation for Thermal and Stress Analysis.

Unit VI:
Computer Aided Engineering: Multiphysics lab simulation for flow induced vibrations.

Texts / References:

1. Ibrahim Zeid and R Sivasubramanian, CAD/CAM: Theory and Practice, McGraw-Hill, Special Indian Edition, 2009
2. Ibrahim Zeid, Mastering CAD / CAM, McGraw-Hill, 2nd Edition, 2006
3. Gerald Farin, Curves and Surfaces for CAGD: A Practical Guide, Elsevier India, 5th Edition, 2013
4. Micheal E. Mortenson, Geometric Modeling,Industrial Press, 3rd Edition, 2006
5. Peter Shirley, Michael Ashikhmin and Steve Marschner, Fundamentals of Computer Graphics, A K Peters/CRC Press, 3rd Edition, 2009
6. David Rogers and J.A. Adams, Mathematical Elements for Computer Graphics, McGraw-Hill, 2nd Edition,2002
7. HartmutPrautzsch and Wolfgang Boehm, Geometric Concepts for Geometric Design, A K Peters/CRC Press, 1993
8. Computational Geometry for Design and Manufacture, Faux I. D. and Pratt M. J., Ellis Horwood, 1980

Computational Fluid Dynamics

MTE23B	Computational Fluid Dynamics	PEC	3-0-0	3 Credits

Exam Scheme

Mid Sem Test	Continuous Assessment	End-Sem Exam	Total
20 Marks	20 Marks	60 Marks	100 Marks

Course Objectives:

1. To Understand the concept of fluid dynamics, CFD techniques, convergence criteria
2. To familiarize the students about the implementation of CFD in fluid mechanics and heat transfer problems
3. To understand the use of software based on CFD

Course Outcomes:

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

CO1	Identify applications of finite volume and finite element methods to solve Navier-Stokes equations.
CO2	Evaluate solution of aerodynamic flows. Appraise & compare current CFD software. Simplify flow problems and solve them exactly.
CO3	Design and setup flow problem properly within CFD context, performing solid using CAD package and producing grids via meshing tool.
CO4	Interpret both flow physics and mathematical properties of governing Navier-Stokes equation and define proper boundary conditions for solution.
CO5	Use CFD software to model relevant engineering flow problems. Analyse the CFD results. Compare with available data, and discuss the findings.

Mapping of COs with POs:

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

Course Contents

UNIT I
Introduction to CFD
Computational approach to Fluid Dynamics and its comparison with experimental and analytical methods, Basics of PDE: Elliptic, Parabolic and Hyperbolic Equations

UNIT II
Governing Equations

Review of Navier-Stokes Equation and simplified forms, Solution Methodology: FDM and FVM with special emphasis on FVM, Stability, Convergence and Accuracy.

UNIT III
Finite Volume Method
Domain discretization, types of mesh and quality of mesh, SIMPLE, pressure velocity coupling, Checkerboard pressure field and staggered grid approach.

UNIT IV
Geometry Modeling and Grid Generation
Practical aspects of computational modeling of flow domains, Grid Generation, Types of mesh and selection criteria, Mesh quality, Key parameters and their importance.

UNIT V
Methodology of CFDHT
Objectives and importance of CFDHT, CFDHT for Diffusion Equation, Convection Equation and Convection-Diffusion Equation.

UNIT VI
Solution of Navier-Stokes Equations for Incompressible Flows
Semi-Explicit and Semi-Implicit Algorithms for Staggered Grid System and Non Staggered Grid System of N-S Equations for Incompressible Flows.

Reference Books:

1. J. D. Anderson, Computational Fluid Dynamics-The Basics with Applications, Mcgraw Hill.
2. An Introduction to Computational Fluid Flow: The Finite Volume Method, by H.K. Versteeg and W. Malalasekera, Prentice Hall
3. Computational Methods for Fluid Dynamics by Ferziger and Peric, Springer Publication
4. Muralidhar K. and Sundararajan T., Computational Fluid Flow and Heat Transfer, Narosa Publishing House, New Delhi1995.
5. S. V. Patankar, Numerical Heat Transfer and Fluid Flow, T & F.
6. An Introduction to Computational Fluid Mechanics by Chuen-Yen Chow, Wiley Publication.

Advanced Refrigeration

MTE23C	Advanced Refrigeration	Elective III	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

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

CO1	Formulate and solve vapor compression refrigeration and multi-stage vapor compression systems.
CO2	Study and identify various types of refrigerants and their properties., such as zeotropic, azeotropic etc.,
CO3	Illustrate Nomenclature, Refrigerants, alternative refrigerants, CFC/HCFC phase-out regulations, action with lubricating oil, retrofitting, refrigerant blends, effects on refrigeration components.
CO4	Design and analyze vapor absorption system
CO5	select refrigerant control techniques,and do piping designing for refrigeration plant

Mapping of course outcomes with program outcomes

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1										
CO2	1											
CO3	1											
CO4						1						
CO5	2	1		1		2						

Course Contents

Unit I:
Vapour compression refrigeration, actual cycle, second law efficiency, multistage compression with inter-cooling, Multi-evaporator systems, Cascade systems.

Unit II:
Performance characteristics and capacity control of reciprocating and centrifugal compressors, screw compressor and scroll compressor.

Unit III:
Design, selection of evaporators, condensers, system balance, control systems, motor selection.

Unit IV:
History, Nomenclature, Refrigerants, alternative refrigerants, CFC/HCFC phase-out regulations, action with lubricating oil, retrofitting, refrigerant blends, effects on refrigeration components. Thermoelectric and nonconventional refrigeration systems, adiabatic de-magnetization

Unit V:
Vapor absorption refrigeration, Li-Br and aqua ammonia system, calculation of mass flow rate and system performance, energy balance, controls, analysis of rectifier and analyzer, single effect and double effect systems,vapour transformer.

Unit VI:
Refrigeration controls, Expansion devices: design and selection, refrigeration system piping design

Texts / References:

1. Stoecker W. F. and Jones J. P.,*Principles of Refrigeration and air-conditioning*, McGraw Hill
2. Arora C. P., *Refrigeration and air-conditioning*, Tata McGraw Hill.
3. Gosney W. B., *Principles of refrigeration*, Cambridge University Press.
4. Stoecker W. F., *H. B. of Industrial refrigeration*, McGraw Hill Companies, Inc.
5. Dossat R. J., Principles of Refrigeration, Pearson Education
6. ASHRAE H. B. – Refrigeration
7. ASHARAE H. B. – Fundamental

Design of Heat Exchangers

MTE23D	Design of Heat Exchanger	Elective III	3-0-0	3 Credits
Exam Scheme				
Class Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks		Total 100 Marks

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

CO1	Demonstrate and of heat exchanger design methodology, and design considerations
CO2	Analyze performance of Heat exchanger by applying basic design theory.
CO3	Design and conduct experiment on one from double pipe, shell and tube, tube fin, plate type and plate-fin heat exchanger.
CO4	Demonstrate selection criteria of HEX and conduct an independent research to suggest suitable HEX.
CO5	Model and illustrate heat exchanger based on I-law and irreversibility.
CO6	Study and analyze losses in HEX, and upcoming advancements.

Mapping of course outcomes with program outcomes

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1							1			
CO2	1	1										
CO3			2						2			
CO4	2	1					1		1			
CO5	1											
CO6	1			1	1							

Course Contents

Unit I:
Introduction: Classification, overview of heat exchanger design methodology, Design specifications, thermo hydraulic design, and other considerations.

Unit II:
Basic design theory: LMTD method, ε-NTU method, P-NTU method, ψ-P method and P1-P2 method.

Unit III:
Heat exchanger design procedures: Design of double pipe, shell and tube, tube fin,plate type and plate-fin heat exchanger.

Unit IV:
Selection of heat exchangers: selection criteria, general selection guidelines of shell and tube heat exchanger, plate type heat exchanger.

Unit V:
Thermodynamic modeling and analysis: modeling of heat exchanger based on I-law and Irreversibility.

Unit VI:
Header design: Flow maldistribution, fouling and corrosion, advances in heat exchangers.

Texts / References:

1. R.K.Shah and DeusanP.Sekulic, *Fundamentals of heat exchanger design*, 2003, John Willeyand Sons.
2. S. Kakac, Heat *Exchangers – Thermal Hydraulic Fundamentals and Design*, Hemisphere, Mc Graw-Hill.
3. D. Q. Kern and A. D. Kraus; *Extended Surface Heat transfer*, McGraw-Hill.
4. W. M. Kays and A. C. London, *Compact Heat Exchangers*, McGraw-Hill.

Alternative Fuels for IC Engine

MTE23E	Alternative Fuels for IC Engine	Elective III	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks		Total 100 Marks

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

CO1	Demonstrate Structure of petroleum, Refining process, Products of refining process, Selec suitable fuels for use in SI engines. Understand various performances rating in SI engines.
CO2	Illustrate properties of petroleum products and classify them on their characteristic.
CO3	Describe and analyze Need for alternative fuels such as Ethanol, Methanol, LPG, CNG Hydrogen and their manufacturing procedure.

CO4	calculate and estimate performance and emission characteristics of alternative fuels
CO5	Analyze environmental effects of combustion of various fuels, suggest modification in thei usage.

Mapping of course outcomes with program outcomes

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2										
CO2		1										
CO3	1	1		1	1							
CO4			1	1								
CO5	1	1			1	1						

Course Contents

Unit I:
Fuels: Introduction, Structure of petroleum, Refining process, Products of refining process, Fuels for spark ignition, Knock rating of SI engine fuels, Octane number requirement, Diesel fuels and Numericals.

Unit II:
Properties of petroleum products: Specific gravity, Density, Mokecular weight, Vapour pressure, Viscosity, Flash point, Fire point, Cloud point, Pour point, Freezing point, Smoke point & Char value, Aniline point, Octane Number, Performance Number, Cetane Number, Emulcification, Oxidation Stability, Acid Value/Number, Distillation Range, and Sulphur content.

Unit III:
Alternative fuels for I.C. engines: Need for alternative fuels such as Ethanol, Methanol, LPG, CNG, Hydrogen, Biogas and Producer gas and their methods of manufacturing**.**

Unit IV:
Single Fuel Engines: Properties of alternative fuels, use of alternative fuels in SI engines, Engine modifications required, Performance and emission characteristics of alternative fuels in SI mode of operation v/s gasoline operation.

Unit V:
Dual fuel Engine: Need and advantages, the working principle, Combustion in dual fuel engines, Factors affecting combustion in dual fuel engine, Use of alcohols, LPG, CNG, Hydrogen, Biogas and Producer gas in CI engines in dual fuel mode. Engine modifications required. Performance and emission characteristics of alternative fuels (mentioned above) in Dual Fuel mode of operation v/s Diesel operation.
Biodiesels: What are biodiesels, Need of biodiesels, Properties of biodiesels V/s petro diesel, Performance and emission characteristics of biodiesels v/s Petro diesel operation.

Unit VI:
Availability: Suitability & Future prospects of these gaseous fuels in Indian context.
Environmental pollution with conventional and alternate fuels, Pollution control methods and packages.

Texts / Reference Books:

1. R.P Sharma &M.L.Mathur: "A Course in Internal Combustion Engines", D.Rai& Sons.
2. O.P. Gupta: "Elements of Fuels, Furnaces & Refractories", Khanna Publishers, 2000.
3. Domkundwar V.M.: "Internal Combustion Engines", I Edition, Dhanpat Rai & Co., 1999
4. John B. Heywood: "Internal Combustion Engines Fundamentals", McGraw Hill International Edition,
5. Osamu Hirao& Richard Pefley: "Present and Future Automotive Fuels", Wiley Interscience Publication. NY. 1988.

Steam and Gas Turbines

MTE24A	Steam and Gas Turbines	Elective IV	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks		Total 100 Marks

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

CO1	Illustrate properties of Steam, Draw P-V, T-s, H-s(Mollier) diagrams for steam, Describe Theoretical steam turbine cycle.
CO2	Demonstrate and analyze vortex flow, energy lines and reheat factors of steam turbines. Solve problems of finding performance steam turbine power plant.
CO3	Demonstrate simple Brayton cycle for gas turbine analyze its performance on computer simulation, suggest suitable modification and then analyze it.
CO4	Study and apply various Performance Improvement Techniques in steam and gas Turbines
CO5	Design and suggest and analyze cooling accessories and protective material for steam turbine.
CO6	Visit thermal power plant and enumerate performance and maintenance and troubleshooting criteria for steam turbine.

Mapping of course outcomes with program outcomes

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1										
CO2		2										
CO3	1	1		3	1							
CO4	2	1			2	1						
CO5	1	1		1	1							
CO6			2	1	1							

Course Contents

Unit I:
Introduction, properties of steam, Theoretical steam turbine cycle. The flow of steam through Impulse and Impulse–Reaction turbine blades

Unit II:
Vortex flow in steam turbines, Energy lines, State point locus, Reheat factor and Design procedure. Governing and performance of steam turbine

Unit III & IV:
Gas turbine, Introduction, simple open cycle gas turbine, Actual Brayton cycle, Means of Improving the efficiency and the specific output of simple cycle, Regeneration, Reheat, Intercooling, closed-cycle gas turbine,turbine velocity diagram and work done.

Unit V:
Turbine blade cooling, material, protective coating, Performance of turbine, Application of turbine.

Unit VI:
Lubrication, cooling, fuel supply and control Maintenance and trouble shooting.

Texts / References:

1. W.J.Kearton, *Steam Turbine Theory and Practice*, ELBS.
2. R.Yadav, *Steam and Gas Turbine*, Central Publishing Home, Allahabad.
3. Jack D. Mattingly., *Elements of Gas Turbine propulsion*, McGraw – Hill Pub.

Cryogenic Engineering

MTE24B	Cryogenic Engineering	PEC	3-0-0	3 Credits
Exam Scheme				
Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

Course Objectives:

- To cover the basic principles of cryogenic engineering.
- To develop an intuitive understanding of cryogenics for the student who are interested to study the science technology of low temperatures.

Course Outcomes:

At the end of the course, student should be able to:

CO1	Demonstrate and identify role of cryogenics in the industrial applications.
CO2	Describe mechanical, thermal, thermo-electric properties of cryogenic fluids.
CO3	Illustrate Ideal separation, properties of mixtures, Rectifiers column, separation of air, purification.
CO4	List and give details about various types of cryogenic refrigeration system, such as J-T Refrigeratio systems, Philips refrigerator, Vuilleumier refrigerator, Solve refrigerator, G-M refrigerator
CO5	Study and describe Insulation and storage systems in cryogenic engineering

Mapping of COs with POs:

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1										
CO2	1	2										
CO3	1	2		1	1							
CO4	1	1		1	1	1						
CO5	1	2			1							

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Course Contents

Unit 1

Introduction:

Industrial applications, research and development, properties of cryogenic fluids-oxygen, nitrogen, air, hydrogen and helium.

Behaviour of Structural Materials at Cryogenic temperature:

Mechanical properties, thermal properties, thermoelectric properties.

Unit 2

Liquefaction of Cryogenic Gases:

Inversion Temperature, Liquefaction Performance Parameters, Ideal cycle, liquefaction of air, Hydrogen and helium, critical components of liquefiers, efficiency, Cryogenic heat exchangers.

Separation of Gases:

Ideal separation, properties of mixtures, Rectifiers column, separation of air, purification.

Unit 3

Cryogenic Refrigeration Systems:

Ideal refrigeration systems, J-T Refrigeration systems, Philips refrigerator, Vuilleumier refrigerator, Solvey refrigerator, G-M regrogerator.

Unit 4

Insulation:

Vacuum insulation, fibrous materials, Solid foams, Gas filled power, comparison, critical thickness.

Unit 5

Storage:

Size and shape of vessel, portable commercial containers, large stationary container, power, transport, storage system, Liquid level indicators.

Unit 6

Transfer of Liquefied Gases:

Two phase flow transfer through insulated and uninsulated lines, cryogenic pumps and valves.

TEXTS:

1. R. F. Barron, Cryogenic Systems, Oxford University Press, 1985.
2. *Advanced Cryogenic Engineering*, Proceedings of Cryogenic Engineering Conference, Vol 1-145, Plenum press, New York, 1968.

Surface Engineering

MME24B	Surface Engineering	Elective IV	3-0-0	3 Credits

Exam Scheme			
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks

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

CO1	Learntheimportanceandneedofsurfaceengineering.
CO2	Describe various surface cleaning and modification techniques.
CO3	Understand the concepts of surface integrity.
CO4	Compare various surface coating technologies.
CO5	Select appropriate method of coating for a given application.
CO6	Apply measurement techniques and carry out characterization of coated surfaces.

Mapping of course outcomes with program outcomes

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2				1	2						
CO2	2		1		1	1						
CO3	2			2		1						
CO4	2					2				2		
CO5	1	2			3	2					1	
CO6	2			2	1	2						

Course Content

Unit I:

IntroductionDefinition, Significance, Role of surface Engineering in creating high performance product, Functional characteristics of a surface, Nature of surfaces: Deformed layer, Beilby layer, chemically reacted layer, Physisorbed layer, Chemisorbed layer; Classification of Surface Engineering Techniques

Unit II:

Surface Preparation Techniques

Factors affecting selection of cleaning process, Significance of surface preparation, Classification of cleaning processes, Chemical cleaning processes; Mechanical Processes; Substrate considerations, Surface contaminants or soils: Various types and their removal, Tests for cleanliness.

Unit III:

Surface Integrity

Definition, Importance, Surface alterations, Factors in Surface Integrity: Visual, Dimensional Residual stress, Tribological, Metallurgical; Measuring Surface Integrity effects: Minimum and Standard data set, Macroscopic and microscopic examination.

Unit IV:

Surface Modification Techniques

Classification, Thermal treatments: Laser and electron beam hardening, Mechanical treatments: Short peening: Peening action, surface coverage and peening intensity, Types and sizes of media, Control of process variables, equipment; Ion Implantation: Basic Principle, Advantages and disadvantages, equipment.

Unit V:

Surface Coating Techniques

Thermal Spraying: Types and applications; Chemical Vapour Deposition: Principles, Reactions, Types and applications; Physical Vapour Deposition: Basic principle, Evaporation, Sputtering, Ion Plating, Applications; Electroplating: Principle of working and applications; Types of Coatings: Hard, Soft, Single layer, Multi-layer.

Unit VI:

Characterization of Coatings

Physical characteristics and their measurements: Coating thickness, Surface Morphology and Microstructure. Mechanical properties and their Measurements: Hardness, Adhesion, Friction and Wear.

Books/References:

1. ASM Handbook, Volume 5: Surface Engineering, ASM International
2. Budinski K. G.; Surface Engineering for Wear Resistance; Prentice Hall
3. Burakowski T. and T. Wierschon; Surface Engineering of Metals: Principles, Equipment, Technologies; CRC Press
4. Bhushan B. and Gupta B. K.; Handbook of Tribology: Materials, Coatings, and Surface Treatments; McGraw Hill
5. ASM Handbook, Volume 16: Machining, ASM International

Nanotechnology

MMECH24C	Nanotechnology	Elective IV	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks		Total 100 Marks

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

CO1	Demonstrate the understanding of length scales concepts, nanostructures and nanotechnology.
CO2	Identify and to compare various synthesis and characterization techniques involved in Nanotechnology.
CO3	Define and interpret the interactions at molecular scale.
CO4	Evaluate and analyze the mechanical properties of bulk nano-structured metals and alloys, nano-composites and carbon nanotubes.
CO5	Compare andanalyze the effects of using nanoparticles over conventional methods.

Mapping of course outcomes with program outcomes

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

Course Contents:

Unit I:

Scientific Revolutions

Types of Nanotechnology and Nano machines: the Hybrid nanomaterial. Multiscale hierarchical structures built out of Nano sized building blocks (nano to macro).Nanomaterials in Nature: Nacre, Gecko, Teeth. Periodic table, Atomic Structure, Molecules and phases, Energy, Molecular and atomic size, Surfaces and dimensional space: top down and bottom up.

Unit II:

Forces between Atoms and Molecules

Particles and grain boundaries, strong Intermolecular forces, Electrostatic and Vander Waals forces between surfaces, similarities and differences between intermolecular and inter particle forces covalent and coulomb interactions, interaction polar molecules, Thermodynamics of self-assembly.

Unit III:

Opportunity at the Nano Scale

Length and time scale in structures, energy landscapes, inter dynamic aspects of inter molecular forces, Evolution of band structure and Fermi surface.

Unit IV:

Quantum dots – Nano wires – Nano tubes - 2D and 3D films - Nano and mesopores, micelles, bilayer, vesicles – bionano machines – biological membranes.

Unit V:

Influence of NanoStructuring

Influence of Nano structuring on mechanical, optical, electronic, magnetic and chemical properties-gram size effects on strength of metals- optical properties of quantum dots.

Unit VI:

Quantum wires - electronic transport in quantum wires and carbon nano-tubes - magnetic behavior of single domain particles and nanostructures – surface chemistry of Tailored monolayer – self assembling.

Texts/References:

1. C. C. Koch, "Nanostructured materials: Processing, Properties and Potential Applications", Noyes Publications, 2002.
2. C. C. Koch, I. A. Ovidko, S. Seal and S. Veprek, "Structural Nano crystalline Materials: Fundamentals & Applications", Cambridge University Press, 2011.

World Class Manufacturing

MME24F	World Class Manufacturing	Elective IV	3-0-0	3 Credits

Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Semester Exam 60 Marks	Total 100 Marks

Pre-Requisites: None
Course Outcomes: At the end of the course the student will be able to:

CO1	Define challenges in world class manufacturing
CO2	Study various world class manufacturing strategies.
CO3	Understand total quality and employee involvement in manufacturing.
CO4	Discuss different world class information system for change management.
CO5	Identify various methods and processes for WCM using brain storming.
CO6	Describe method to monitor performance in WCM.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2											1
CO2	2				1							1
CO3	2				1							1
CO4	2			1	1		1					
CO5	2				1		1			1	1	
CO6	2			1			1			1	1	

Course Contents:

Unit 1.
- Historical perspective: World class Excellent organizations – Models for manufacturing excellence – Business Excellence.

Unit 2.
- Benchmark, Bottlenecks and Best Practices: Concepts of benchmarking, bottleneck and best practices, Best performers – Gaining competitive edge throughworld class manufacturing – Value added manufacturing – eliminating waste – Toyota Production System – example.

Unit 3.
- System & tools for world class manufacturing: Improving Product & Process Design – Lean Production – SQC , FMS, Rapid Prototyping , Poka Yoke , 5-S ,3 M, use of IT ,JIT, Product Mix , Optimizing , Procurement & stores practices , Total Productive maintenance , Visual Control.

Unit 4.
- Human Resource Management in WCM: Adding value to the organization – Organizational learning – techniques of removing Root cause of problems – People as problem solvers –

New organizational structures . Associates – Facilitators –Teamsmanship – Motivation and reward in the age of continuous improvement.

Unit 5.

- Typical characteristics of WCM companies: Performance indicators – what is world class Performance – Six Sigma philosophy

Unit 6.

- Indian Scenario: Leading Indian companies towards world class manufacturing – Task Ahead.

TEXTS / REFERENCES:

1. World Class Manufacturing - Strategic Perspective - B.S. Sahay ,KBC Saxena , Ashish Kumar(Mac Millan)
2. Making Common Sense Common Practice – Models for manufacturing excellence-Ron Moore (Butter worth Heinmann)
3. The Toyota Way - Jeffrey K.Liker – (Tata Macgraw Hill)
4. Operations Management for Competitive Advantage – Chase
5. Making Common Sense Common Practice – Moore
6. Managing Technology & Innovation for Competitive Advantage – Narayanan
7. Just In Time Manufacturing – M.G.Korgaonkar
8. Machine That Changed The World – Womack

Research Methodology

MOE25A	Research Methodology	Open Elective	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks		Total 100 Marks

Course Objectives:

1. To Understand the concept of research, paper writing, similarities, etc
2. To familiarize the students about the statistical methods, data interpretation , error analysis
3. To carry out analysis on the a published paper

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

CO1	Understand and Describe importance of research.
CO2	Classify and select appropriate resources for Research.
CO3	Analyze the contents of literature and identify further scope.
CO4	Formulate a Research Problem.
CO5	Develop effective written and oral Presentation skills.

Mapping of COs with POs:

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

Course Content:

Unit I:
Research Concepts – concepts – meaning – objectives – motivation. Types of research – descriptive research – conceptual research – theoretical research – applied research – experimental research.

Unit II:
Research process – Criteria for good research – Problems in Indian context. Formulation of Research Task – Literature Review – Importance & Methods – Sources – Quantification of Cause Effect Relations – Discussions– Field Study – Critical Analysis of Facts Generated

Unit III:
Hypothetical proposals for future development and testing, selection of Research task.

Unit IV:
Mathematical modelling and simulation – Concepts of modelling – Classification of

mathematical models – Modelling with – Ordinary differential equations – Difference equations – Partial differential equations – Graphs – Simulation – Process of formulation of model based on simulation.

Unit V:
Interpretation and report writing – Techniques of interpretation – Precautions in interpretation- Significance of report writing – Different steps inreport writing – Layout of research report – Mechanics of writing research report – Layout and format – Style of writing – Typing – References – Tables – Figures – Conclusion – Appendices.

Unit VI:
Applications of statistical methods in research

Texts/ References:

1. J.W Bames, Statistical Analysis for Engineers and Scientists, McGraw Hill, N.York
2. Schank Fr., Theories of Engineering Experiments, Tata Mc Graw Hill Publication.
3. C. R. Kothari, Research Methodology, New Age Publishers.
4. Willktnsion K. L, Bhandarkar P. L, Formulation of Hypothesis, Himalaya Publication.

Design of Experiments

MOE25B	Design of Experiments	Open Elective	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks		Total 100 Marks

Course Objectives:

1. To Understand the concept of design of experiments
2. To familiarize the students about the design of experiments techniques and their implementation
3. To design and analysis a real life problem using technique .

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

CO1	Define Taguchi, factorial experiments, variability, orthogonal array, quality loss.
CO2	Plan and design the experimental investigations efficiently and effectively.
CO3	Understand strategy in planning and conducting experiments.
CO4	Evaluate variability in the experimental data using ANOVA.
CO5	Practice statistical software to achieve robust design of experiments.

Mapping of COs with POs:

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1		1	1	1	1	1		1		1
CO2	2	1	1			1		1				
CO3		2	1			1			1			

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

Course Contents

Unit I:
Introduction: Modern quality control, quality in engineering design, history of quality engineering.
The Taguchi Approach to quality: Definition of quality, loss function, off-line and on-line quality control, Taguchi`s quality philosophy.

Unit II:
Full Factorial Designs: Experimentation as learning process, traditional scientific experiments, three factor design, replicating experiments, factor interactions, normal plots of estimated effects, mechanical plating experiments, two factor design, four factor design, Taguchi design and western design.

Unit III:
Fractional Factorial Design: Fractional factorial design based on eight run experiments, folding over an eight run experimental design, Fractional factorial design in sixteen run, folding over an sixteen run experimental design, blocking two level designs, other two level designs.

Unit IV:
Evaluating Variability: Necessity to analyze variability, measures of variability, the normal distribution, using two level designs to minimize variability, signal-to-noise ratio, minimizing variability and optimizing averages.
Taguchi Inner and Arrays: Noise factors, experimental designs for control and noise factors, examples.

Unit V:
Experimental Design for Factors at Three and Four level: Necessity to use more than two level, factors at four levels, factors at three levels.
Analysis of Variance in Engineering Design: Hypothesis testing concepts, using estimated effects as test statistics, analysis of variance for two level designs, when to use analysis of variance.

Unit VI:
Computer Software for Experimental Design: Role of computer software in experimental design, summery of statistical packages, example of use of software packages.
Using Experiments to improve Processes: Engineering design and quality improvement, steps to implementing use of engineering design.

Texts / References:
1. D.C.Montgomery, *Design and Analysis of Experiments*, 5th Edition, John Wiley and Sons, NewYork, 2004.
2. R.H.Lochner and J.E.Matar, *Designing for Quality: An Introduction to the Best of Taguchi and Western Methods of Statistical Experimental Design*, Chapman and Hall, London, 1983.

Advanced Optimization Techniques

MOE25C	Advanced Optimization Techniques	Open Elective	3-0-0	3 Credits

Exam Scheme			
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks

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

CO1	Enables to acquire mathematical methods and apply in engineering disciplines.
CO2	Apply methods of optimization to solve a linear,non-linear programming problem by variou methods
CO3	Optimize engineering problem of nonlinear-programming with/without constraints, by usin this technique.
CO4	Use of dynamic programming problem in controlling in industrial managements.
CO5	Simulate Thermal engineering system problem. Understand integer programming an stochastic programming to evaluate advanced optimization techniques.

Mapping of course outcomes with program outcomes

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1						1		1		1
CO2	2	1	1					1				
CO3		2							1			
CO4	1				2	1				2		1
CO5			1	2	1	1	2		1	2		1

Course Contents

Unit I:

Single Variable Non-Linear Unconstrained Optimition: One dimensional Optimization methods, Uni-modal function, elimination method, Fibonacci method, golden section method, interpolation methods- quadratic & cubic interpolation methods.

Unit II:

Multi Variable Non-Linear Unconstrained Optimization: Direct search method – Univariant Method – pattern search methods – Powell's – Hook – Jeeves, Rosenbrock search methods – gradient methods, gradient of function, steepest decent method, Fletcher reeves method.Variablemetric method.

Unit III:

Geometric Programming: Polynomials – arithmetic – geometric inequality – unconstrained G.P– constrained G.P

Dynamic Programming: Multistage decision process, principles of optimality, examples, conversion of final problem to an initial value problem, application of dynamic programming, production inventory. Allocation, scheduling replacement.

Unit IV:
Linear Programming: Formulation – Sensitivity analysis. Change in the constraints, cost coefficients, coefficients of the constraints, addition and deletion of variable, constraints. **Simulation**: Introduction – Types – Steps – application – inventory – queuing – thermal system.

Unit V:
Integer Programming: Introduction – formulation – Gomory cutting plane algorithm – Zero or one algorithm, branch and bound method.
Stochastic Programming: Basic concepts of probability theory, random variables – distributions – mean, variance, Correlation, co variance, joint probability distribution stochasticlinear, dynamic programming.

Text Books/References:

1. Optimization theory & Applications/ S.S Rao/ New Age International
2. Introductory to operation research/Kasan& Kumar/Springer
3. Optimization Techniques theory and practice / M.C Joshi, K.M Moudgalya/ Narosa Publications.
4. Operation Research/H.A. Taha/TMH
5. Optimization in operations research/R. LRardin
6. Optimization Techniques/Benugundu&Chandraputla/Person Asia
7. Optimization Techniques /Benugundu&Chandraputla / Pearson Asia

Environmental Engineering and Pollution Control

MOE25D	Environmental Engineering and Pollution Control	Open Elective	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks		Total 100 Marks

Course Objectives:

1. To Understand the need of pollution control, its impact, control
2. To familiarize the students about the pollution control techniques
3. To carry out the real life problem

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

CO1	Identify effects of industrialization on environmental pollution in various field.
CO2	Describe photochemical smog, acid Rain, Greenhouse effect, ozone depletion, globa warming.
CO3	Suggest pollution control techniques for vehicles, refrigeration, industries, chemical and power plant.
CO4	Do Case study on any industry and analyze carbon exertion rate, water pollution, soil pollution etc.
CO5	Design pollution control devices for vehicle, analyze and find out replacement CFC refrigerant with HC refrigerant.

Mapping of COs with POs:

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2										
CO2	2											1
CO3				1			2	1				1
CO4	2					2			1			
CO5						1						2

Course Content:

Unit I:
Impact of industrialization and modernization - pollution and pollutants. Air pollution and its effects - air pollution - sources - pollutants – organic and inorganic pollutants - gaseous pollutants– nitrogen oxides - particulate pollutants - effect of pollutants on plants – animals and human beings.

Unit II:
photochemical oxidants - photochemical smog – acid Rain - Green house effect - ozone depletion - global warming -Environmental pollution techniques for air pollution - monitoring and Control measures of air pollution - dust control equipment - Electrostatic precipitators and scrubbers.

Unit III:
Water pollution and its effects structure - water pollution - sources -Pollutants - industrial effluents - domestic wastes - agrochemicals -Heavy metals - effect of pollutants on plants - animals and human beings Bod - eutrophication - waste water treatment - indicator orgnisms -Oxidation pond - water pollution analysis and monitoring – drinking Water standards. Soil pollution and its effects - soil pollution - sources - solid waste Disposal and their effects - pesticides - types and effect of pollutants on Plants - animals and human beings - biomagnification - fertilizers and its Effect of pollutants on plants - animals and human beings –

Unit IV:
soil pollution Control measures - soil microbes and function - biofertilizer. Noise pollution and its effects - noise pollution - sources – noise Exposure level and standards - impacts - noise control and abatement Measures.

Unit V:
Marine pollution - sources and control of marine pollution – criteria Employed for disposal of pollutants in marine system – coastal Management. Radioactive pollution and its impacts - radioactive - sources - effect of Pollutants of plants - animals and human beings - prevention and control Measures of radioactive pollution.

Unit VI:
Assessment and control of pollution - environmental standards - Assessment of pollution effects due to air - water - soil and radioactive Pollution - biotechnology in pollution control - microbial role in Pollution control - biomonitoring and bioremediation - pollution control

Legislations for air - water - land etc. Biotechnology in pollution control - bioremediation (organic and Inorganic pollutants) - bioleaching and biomineralization.

Text/References:

1. Environmental Pollution Analysis:Khopkar.
2. Environmental Science – A study of Inter relationships, E. D. Enger, B. E. Smith, 5th ed., W C B publication.
3. Environmental Pollution Control Engineering: C. S. Rao
4. Bruce Rittman, Perry L. McCarty. Environmental Biotechnology: Principles and Applications, 2nd Edition, McGraw-Hill, 2000.
5. J.N.B. Bell (2002) Air Pollution and Plant Life, 2nd Edition, John Wiley and Sons, New Delhi.

Soft Computing Techniques

MOE25E	Soft Computing Techniques	Open Elective	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks		Total 100 Marks

Pre-Requisites: None

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

CO1	Classify different optimization and evolutionary algorithms.
CO2	Apply optimization techniques to real life problems.
CO3	Learn and apply neural network prediction algorithm to solve engineering problems.
CO4	Understand and apply fuzzy based logic function for predicting results.
CO5	Acquire and use knowledge of genetic algorithm to optimize real life problems.
CO6	Study different hybrid soft computing methods and its applications.

Mapping of course outcomes with program outcomes

Program Outcomes→ Course Outcomes ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2		2							1		2
CO2	2	2	2	2						1		2
CO3	2	2	2	2						1		
CO4	2	2	2	2						1		
CO5	2	2	2	2						1		
CO6	2	2	2	2						1		1

Course Content:

Unit I:
INTRODUCTION: Soft Computing: Introduction of soft computing, Evolutionary Algorithms vs. Convectional optimization techniques, various types of soft computing techniques, applications of soft computing. Artificial Intelligence: Introduction, Various types of production systems, characteristics of production systems, breadth first search, depth first search techniques, other Search Techniques like hill Climbing, Best first Search, A* algorithm, AO* Algorithms and various types of control strategies. Knowledge representation issues, Prepositional and predicate logic, monotonic and non-monotonic reasoning, forward Reasoning, backward reasoning.

Unit II:
OPTIMIZATION CONCEPTS: Objective functions, constraints, Search space, local optima, global optima, fitness functions, search techniques, etc.

Unit III:
NEURAL NETWORKS**:** Artificial neural network: Introduction, characteristics- learning methods – taxonomy – Evolution of neural networks- basic models – important technologies – applications. McCulloch-Pitts neuron – linear separability – hebb network – supervised learning network: perceptron networks – adaptive linear neuron, multiple adaptive linear neuron, BPN, RBF, TDNN- associative memory network: auto-associative memory network, hetero-associative memory network, BAM, hopfield networks, iterative auto-associative memory network & iterative associative memory network – unsupervised learning networks: Kohonenself organizing feature maps, LVQ – CP networks, ART network.

Unit IV:
FUZZY LOGIC**:** Fuzzy logic: Introduction – crisp sets- fuzzy sets – crisp relations and fuzzy relations: cartesian product of relation – classical relation, fuzzy relations, tolerance and equivalence relations, non-iterative fuzzy sets. Membership functions: features, fuzzification, methods of membership value assignments- Defuzzification: lambda cuts – methods – fuzzy arithmetic and fuzzy measures: fuzzy arithmetic – extension principle – fuzzy measures – measures of fuzziness -fuzzy integrals – fuzzy rule base and approximate reasoning : truth values and tables, fuzzy propositions, formation of rules-decomposition of rules, aggregation of fuzzy rules, fuzzy reasoning-fuzzy inference systems-overview of fuzzy expert system-fuzzy decision making.

Unit V:
GENETIC ALGORITHM**:** Genetic algorithm- Introduction – biological background – traditional optimization and search techniques – Genetic basic concepts. Genetic algorithm and search space – general genetic algorithm – operators – Generational cycle – stopping condition – constraints – classification genetic programming – multilevel optimization – real life problem- advances in GA.

Unit VI:
HYBRID SOFT COMPUTING TECHNIQUES & APPLICATIONS**:** Neuro-fuzzy hybrid systems – genetic neuro hybrid systems – genetic fuzzy hybrid and fuzzy genetic hybrid systems – simplified fuzzy ARTMAP – Applications: A fusion approach of multispectral

images with SAR, optimization of traveling salesman problem using genetic algorithm approach, soft computing based hybrid fuzzy controllers.

Texts/References:

1. J.S.R.Jang, C.T. Sun and E.Mizutani, "Neuro-Fuzzy and Soft Computing", PHI /Pearson Education 2004.
2. S.N.Sivanandam and S.N.Deepa, "Principles of Soft Computing", Wiley India Pvt Ltd, 2011.
3. S.Rajasekaran and G.A.VijayalakshmiPai, "Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis & Applications", Prentice-Hall of India Pvt. Ltd., 2006.
4. George J. Klir, Ute St. Clair, Bo Yuan, "Fuzzy Set Theory: Foundations and Applications" Prentice Hall, 1997.
5. David E. Goldberg, "Genetic Algorithm in Search Optimization and Machine Learning" Pearson Education India, 2013.
6. James A. Freeman, David M. Skapura, "Neural Networks Algorithms, Applications, and Programming Techniques, Pearson Education India, 1991.
7. Simon Haykin, "Neural Networks Comprehensive Foundation" Second Edition, Pearson Education, 2005.

Manufacturing Automation

MOE25F	Manufacturing Automation	Open Elective	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks		Total 100 Marks

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

CO1	Understand the concept of automation and human factors
CO2	Designing a Pneumatic and Hydraulic system for a given application
CO3	Demonstrate the use of different sensors for automation
CO4	Designautomation systems for a given application
CO5	Understand the circuit optimization techniques

Mapping of course outcomes with program outcomes

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

Course Contents

Unit I:
Product cycle, manufacturing functions, types of automation, degree of automation, technical, economic and human factors in automation.

Unit II:
Technologies- mechanical, electrical, hydraulic, pneumatic, electronic, hybrid systems, comparative evaluation.

Unit III:
Development of small automation systems using mechanical devices, synthesis of hydraulic circuits.

Unit IV:
Circuit optimization techniques, illustrative examples of the above types of systems

Unit V:
Industrial logic control systems logic diagramming, programmable controllers.

Unit VI:
Applications, designing for automation, cost-benefit analysis.

Texts / References:

1. A.N.Gavrilov, *Automation and Mechanization of Production Processes in Instrument Industry*, Pergaman Press, Oxford, 1967.
2. G.Pippengerm, *Industrial Hydraulics*, MGH, New York, 1979.
3. F.Kay ,*Pneumatics for Industry*, The Machining Publishing Co., London,1969.
4. Ray, *Robots and Manufacturing Assembly*, Marcel Dekker, New York, 1982.

Modeling and Simulation

MOE25G	Modeling and Simulation	Open Elective	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks		Total 100 Marks

Pre-Requisites: None

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

CO1	Define simulation, its limitations and applications.
CO2	Apply simulation to queuing and inventory situations.
CO3	Acquire knowledge to generate the random numbers for simulation models.
CO4	Analyze the data and verify model of simulation.
CO5	Learn software's and programming languages for developing simulation model.
CO6	Discuss case studies in manufacturing simulation.

Mapping of course outcomes with program outcomes

Program Outcomes→ / Course Outcomes ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2											1
CO2	2			1								
CO3	2	2	1	2								1
CO4	2	2	1	2						2	1	
CO5	2	2	2	3						1		2
CO6	2						2			1		

Course Contents:

Unit I:
Introduction to systems and modeling – discrete and continuous system - Limitations of simulation, areas of application - Monte Carlo Simulation.

Unit II:
Discrete event simulation and their applications in queueing and inventory problems.

Unit III:
Random number generation and their techniques - tests for random numbers. Random variable generation.

Unit IV:
Analysis of simulation data. - Input modeling – verification and validation of simulation models – output analysis for a single model.

Unit V:
Simulation languages and packages - FORTRAN, C, C++, GPSS, SIMAN V, MODSIM III, ARENA, QUEST, VMAP - Introduction to GPSS – Case studies.

Unit VI:
Simulation of manufacturing and material handling system, Caste studies.

Texts/References:

1. Jerry Banks and John S, Carson II "Discrete Event System Simulation", Prentice Hall, 1984.
2. Geoffrey Gordon., "System Simulation", Prentice Hall, 1978.
3. Francis Neelamkovil, "Computer Simulation and Modelling", John Willey and sons,1987.

Seminar

MMECH26	Seminar	PCC	0-0-4	2 Credits
Exam Scheme				
Continuous Assessment		End-Sem Evaluation (OR)		Total

50 Marks	50 Marks	100 Marks

Course Objectives:

1. To understand the open literature
2. To familiarize the students about collection of technical literature, reading and understanding
3. To learn the report writing and presentation

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

CO1	Identify the topic for seminar from the recent areas and technologies in thermal and fluids engineering or related areas.
CO2	Carry out detailed comprehensive survey of the literature related to the topic selected. Use information available from various sources like research papers, patents, websites, discussion with experts on the topic etc.
CO3	Comprehend the information, organize it and write technical report. Give presentations on the topic to the group of students.
CO4	Identify and report latest developments and unresolved issues in the selected topic/area.
CO5	Analyze the impact of the technologies on the environment. Identify green technologies related to selected topic.

Mapping of course outcomes with program outcomes

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

Course Contents:

The seminar shall consist of the preparation of the report by the candidate on the topic mutually decided by himself and the supervisor. The topic should be a problem in the field of Mechanical Engineering and should have the sufficient research orientation. The recent development in the field of the chosen topic needs to be understood by the candidate. The report has to be presented in front of the examiners committee and other faculty members and students of the department. The committee should be set by the PG coordinator and Head, Mechanical Engineering for evaluation of seminar.

Mini Project

MMECH27	Mini Project	PCC	3-1-0	4 Credits
Exam Scheme				
Continuous Assessment 50 Marks		End-Sem Evaluation (PR/OR) 50 Marks		Total 100 Marks

Course Objectives:

1. To apply the basic engineering laws through a modeling/ model/setup
2. To understand the report writing and result analysis
3. To understand the problem formulation

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

CO1	Identify methods and materials to carry out experiments/develop code.
CO2	Reorganize the procedures with a concern for society, environment and ethics.
CO3	Analyze and discuss the results to draw valid conclusions.
CO4	Prepare a report as per recommended format and defend the work
CO5	Explore the possibility of publishing papers in peer reviewed journals/conference proceedings.

Mapping of course outcomes with program outcomes

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

Objectives:

To train students in identification, analysis, finding solutions and execution of live Mechanical Engineering and Managerial problems. It is also aimed to enhance the capabilities of the students.

Individual students are required to choose a topic of their interest. The subject content of the mini project shall be from emerging / thrust areas, topics of current relevance having research aspects or shall be based on industrial visits. Students can also choose live problems from Mechanical Engineering as their mini project. At the end of the semester, the students should submit a report duly authenticated by the respective guide, to the head of the department.
Mini Project will have internal marks 50 and Semester-end examination marks 50.

Internal marks will be awarded by respective guides as per the stipulations given below.
Attendance, regularity of student (20 marks)
Individual evaluation through viva voce / test (30 marks)
Total (50 marks)

Semester end examination will be conducted by a committee consisting of three faculty members. The students are required to bring the report completed in all respects duly authenticated by the respective guide and head of the department, beforethe committee. Students individually will present their work before the committee. The committee will evaluate the students individually and marks shall be awarded as follows.

Report = 25 marks

Concept/knowledge in the topic = 15 marks

Presentation = 10 marks

Total marks = 50 marks

Semester-III
Project Management

MMECH31	**Project Management**	**PCC**	**0-0-0**	**2 Credits**

Continuous Assessment 50 Marks	PR/OR 50 Marks	Total 100 Marks

Pre-Requisites: None
Course Outcomes: At the end of the course the student will be able to:

CO1	
CO2	
CO3	
CO4	
CO5	
CO6	

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

Course Contents:

Unit-1

- Introduction to Project management**:** Characteristics of projects, Definition and objectives of Project Management, Stages of Project Management, Project Planning Process, Establishing Project organization. Work definition: Defining work content, Time Estimation Method, Project Cost Estimation and budgeting, Project Risk Management, Project scheduling and Planning Tools: Work Breakdown structure, LRC, Gantt charts, CPM/PERT Networks.

Unit-2

- Developing Project Plan (Baseline), Project cash flow analysis, Project scheduling with resource constraints: Resource Leveling and Resource Allocation. Time Cost Trade off: Crashing Heuristic.

Unit-3

- Project Implementation: Project Monitoring and Control with PERT/Cost, Computers applications in Project Management, Contract Management, Project Procurement Management. Post-Project Analysis.

TEXT BOOKS/REFERENCES:

1. Shtub,BardandGloberson,ProjectManagement:Engineering,Technology,andImplementation,Prentice Hall, India
2. Lock, Gower, Project Management Handbook.

Intellectual Property Rights

MMECH32	**Intellectual Property Rights**	**PCC**	**0-0-0**	**2 Credits**

Continuous Assessment 50 Marks	PR/OR 50 Marks	Total 100 Marks

Pre-Requisites: None
Course Outcomes: At the end of the course the student will be able to:

CO1	Enumerate and demonstrate fundamental terms such as copy-rights ,Patents ,Trademarks etc.,
CO2	Interpret and follow Laws of copy-rights, Patents, Trademarks and various IP registration Processes to register own project research.
CO3	exhibit the enhance capability to do economic analysis of IP rights, technology and innovation related policy issues and firms' commercial strategies.
CO4	Develop awareness at all levels (research and innovation) of society to develop patentable technologies.
CO5	Apply trade mark law, copy right law, patent law and also carry out intellectual property audits
CO6	Manage and safeguard the intellectual property and protect it against unauthorized use

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1					1		1			
CO2	1		2				1		2			2
CO3						1		1				
CO4						1			1			
CO5			1						1			1
CO6												

Course Contents:

Unit-1

- Introduction to IPR; Overview & Importance; IPR in India and IPR abroad; Patents ;their definition; granting; infringement ;searching & filing; Utility Models an introduction;

Unit-2

- Copyrights ; their definition; granting; infringement ;searching & filing, distinction between related and copy rights; Trademarks ,role in commerce ,importance , protection, registration; domain names;

Unit-3

- Industrial Designs ; Design Patents; scope; protection; filing infringement; difference between Designs & Patents' Geographical indications , international protection; Plant varieties; breeder's rights, protection; biotechnology& research and rights managements; licensing, commercialization; ; legal issues, enforcement ;Case studies in IPR.

TEXT BOOKS/REFERENCES:

1. Prabuddha Ganguli, IPR: Unleashing the Knowledge Economy, published by Tata McGraw Hill 2001.

Project Stage-I

MMECH33	Project Stage-I	PCC	0-0-0	10 Credits
Exam Scheme				
Continuous Assessment 50 Marks		End-Sem Evaluation 50 Marks		Total 100 Marks

Course Objectives:

1. To learn the literature survey
2. To familiarize the students about understanding the open literature, preparation of literature review etc
3. To understand the problem formulation based on the literature review

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

CO1	Identify problems and to plan methodologies to solve problems.
CO2	Carry out exhaustive literature review, study &evaluate collected literature critically and identify the gaps based on the review.
CO3	Select the specific problem for the study as a project
CO4	Demonstrate technical writing while preparing project report and present it to evaluation committee to demonstrate presentation skills acquired.

Mapping of course outcomes with program outcomes

POs→ COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		2		2	1							
CO2			3			1						
CO3	1	3				1						
CO4								3			2	1

Course Contents:

Project (stage-I) should be based on the area in which the candidate has undertaken the dissertation work as per the common instructions for all branches of M. Tech. The examination shall consist of the preparation of report consisting of a detailed problem statement and a literature review. The preliminary results (if available) of the problem may also be discussed in the report. The work has to be presented in front of the examiners panel set by Head and PG coordinator. The candidate has to be in regular contact with his guide and the topic of dissertation must be mutually decided by the guide and student

Semester IV
Project Stage-II

MMECH41	Project Stage-II	PCC	0-0-40	20 Credits
Exam Scheme				
Continuous Assessment 100 Marks	PR/OR 100 Marks	Total 200 Marks		

Course Objectives:

1. To develop the setup/model based on the literature survey
2. To familiarize the students about the carrying out experimentation/ computer programmimg/ software
3. To understand the report writing, analysis of result, preparation of manuscript etc

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

CO1	Solve identified technical problem using acquired knowledge and skill.
CO2	Use latest equipment, instruments, software tools, infrastructure and learning resources available to solve the identified project problem.Procure resources, if required.
CO3	Interpret theoretical/experimental findings using available tools
CO4	Compare the results obtained with results of similar studies
CO5	Draw conclusions based on the results.

Mapping of course outcomes with program outcomes

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

Course Contents

Project stage-I should be based on the area in which the candidate has undertaken the dissertation work as per the common instructions for all branches of M. Tech. The examination shall consist of the preparation of report consisting of a detailed problem statement and a literature review. The preliminary results (if available) of the problem may also be discussed in the report. The work has to be presented in front of the examiners panel set by Head and Faculty Advisor. The candidate has to be in regular contact with his guide and the topic of dissertation must be mutually decided by the guide and student.