Kolhapur Institute of Technology's College ofEngineering (Autonomous), Kolhapur

Curriculum

(Syllabus)for

T.Y.B.TECH
Mechanical Engineering
Programme(Under Graduate Programme) From Academic Year 2023-2024

Title of the Course: HEAT TRANSFER	L	T	P	Credit
Course Code: UMEC0501	3	-	-	3

Course Pre-Requisite: Differential calculus, integral calculus, Fluid mechanics.

Course Description: The course deals with fundamentals aspects of heat transfer. The knowledge of heat transfer in necessary for design of thermal equipments in the industry and simulation using Computational Fluid dynamics and Heat transfer.

Course Objectives:

1. To prepare students of Mechanical Engineering to excel in heat transfer problems related to thermal Engineering so as to succeed in careers in industry, technical professions or entrepreneurship.
2. To provide students with a solid foundation in mathematics, science and engineering fundamentals required to solve engineering problems in heat and also to pursue higher studies.
3. To train students with good scientific and engineering breadth in the areas of heat transfer so as to comprehend, analyze, design and create novel products and solutions for the real life problems.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Bloom's Cognitive Descriptor
CO1	Explain fundamentals of Heat and Mass Transfer mechanisms.	2	Understanding
CO2	Develop differential equations for Heat Transfer mechanisms.	3	Applying
CO3	Analyze the performance of heat transfer devices.	4	Analyzing
CO4	Estimate the rate of heat transfer at specified temperature difference.	5	Evaluating

CO-PO,PSO Mapping:

CO	PO1	PO2	PO3	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	-	-	-	-	-	-	-	2	-	1
CO2	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	3	-	-	-	-	-	-	2	-	-	-	3	2	-
CO4	-	3	-	-	-	-	-	-	-	-	-	1	3	2	-

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10

MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

UNIT 1: BASICS OF HEAT TRANSFER AND ONE DIMENSIONAL STEADY STATE HEAT CONDUCTION **Basics of Heat Transfer:** Thermodynamics and Heat Transfer, Heat Transfer Mechanisms and Basic Laws Simultaneous Heat Transfer Mechanisms. Problem Solving Techniques in Heat Transfer. **Heat Conduction Equation:** General Heat Conduction Equation: Rectangular Coordinates, Cylindrical Coordinates and Spherical Coordinates. **One Dimensional Steady State Heat Conduction without Heat Generation:** Plane Wall, Cylinder, Sphere. Boundary and Initial Conditions. Concept of Thermal Resistance Thermal Contact Resistance, Overall Heat Transfer Coefficient. Critical Radius of Insulation. **One Dimensional Steady State Heat Conduction With Heat Generation:** Plane Wall, Cylinder and Sphere.	08 **Hrs.**
UNIT 2: ONE DIMENSIONAL UNSTEADY STATE HEAT CONDUCTION AND EXTENDED SURFACES: **Transient Heat Conduction:** Lumped System Analysis, Significance of Biot and Fourier Number. **Extended Surfaces (Finned Surfaces):** Types of fins, applications, Expression for Heat Transfer, Temperature Distribution, fin efficiency and Fin effectiveness basedfin tip condition, Error estimation in Thermowell.	06 **Hrs.**
UNIT 3: CONVECTION **Fundamentals of Convection:** Physical Mechanism of Convection, Velocity and Thermal Boundary Layer, Reynolds and Chilton-Colburn Analogy. Buckingham's Pi Theorem applied to Forced and Free Convection, Physical Significance of dimensionless numbers. **External Forced Convection:** Local and Average Heat Transfer Coefficient, Parallel Flow over Flat Plates, Flow across Cylinders and Spheres. **Internal Forced Convection:** Mean Velocity and Mean Temperature, Laminar Flow in tubes, Turbulent Flow in Tubes. **Natural Convection:** Physical Mechanism of natural Convection, Natural Convection Over surfaces. Natural Convection inside enclosures. Combined Natural Convection and Radiation. Combined Natural and Forced Convection.	06 **Hrs.**
UNIT 4: THERMAL RADIATION **4.1 Fundamentals of Thermal Radiation:** Nature of radiation, electromagnetic wave spectrum, Black Body Radiation, Laws of Radiation, Radiation Intensity, Irradiation,	08 **Hrs.**

Radiosity, Spectral Quantities, Radiative Properties, The Greenhouse Effect. **4.2 Radiation Heat Transfer:** View Factor, Radiation Heat Transfer Between Black Surfaces, Radiation Heat Transfer Between Non-Black Surfaces, Radiation Shields, Problem Solving using Electrical Analogy, Radiation Effect on Temperature Measurements.	
UNIT 5: HEAT EXCHANGERS Types of Heat Exchangers, Overall Heat Transfer Coefficient, Effect of Fouling, Analysis of Heat Exchangers (Parallel and Counter Flow); LMTD and Effectiveness NTU Methods, Multi pass and Cross Flow Heat Exchangers. Selection of Heat Exchangers.	08 **Hrs.**
UNIT 6: COOLING OF ELECTRONIC EQUIPEMENT Introduction and History, Importance of Heat Transfer in Electronics, Cooling Load of Electronic Equipment, Conduction Cooling, Air Cooling, Liquid Cooling, Immersion Cooling, Heat Pipes, Thermoelectric Coolers, Electrohydrodyanmic Flow, Synthetic Jet, Microchannel Cooling, Cooling by nano fluids.	04**Hrs.**

Textbooks:

1. Heat Transfer: A Practical Approach**,** Yunus A. Cengel , McGraw-Hill Higher Education; 2 edition

2. Fundamentals of Heat & Mass Transfer ,7th Edition, Frank P. Incropera, Wiley.

3. A Course in Heat and Mass Transfer,: S. C. Arora (Author), S. Domkundwar (Author), Anand V. Domkundwar

4 Heat and Mass transfer**:** J Holman (Author), Souvik Bhattacharyya , McGraw Hill Education; 10 edition

5. Heat Transfer- Thermal Management of Electronics, Younes Shabany, CRC Press, Indian Edition.

References:

1 Fundamentals of Engineering Heat and mass trasnfer, R C Sachdeva, NEW AGE; Fourth edition

2. Heat And Mass Transfer, Data Book, C.P. Kothandaraman, New Age International Private Limited; Ninth edition.

Unit wise Measurable students Learning Outcomes:

1. Graduates will be able to formulate and solve basic equations of steady state conduction heat transfer problems

2. Graduates will be able to identify, define, formulate, and solve transient state conduction heat transfer and extended surface problems

3 . Graduates will be able to identify, define, formulate, and solve convection problems

4. Graduates will be able to demonstrate fundamental knowledge and formulate, and solve radiation heat transfer problems

5 .Graduates will be able to design a heat exchanger per user defined needs and specifications.

6. Graduates will be able to explain the fundamentals of electronic cooling techniques.

Title of the Course: Metrology & Quality Control	L	T	P	Credit
Course Code: UMEC0502	3	-	-	3

Course Pre-Requisite:

This course requires the basic knowledge of the following:

1. Metric and SI units of physical quantities
2. Statistics
3. Trigonometry and basics of manufacturing engineering

Course Description:

In the era of technology driven life. Product are need to be manufactured with high accuracy and precision and for accomplishing this dimensional control and measurement of it with the desired accuracy and precision is demanded. Also this is the very important aspect in achieving quality and reliability in the service of any product. Unless the manufactured parts are accurately measured, assurance of quality cannot be granted. In this context measuring instruments and precision measurement techniques plays significant role.

This course covers this all the demanded aspects of syllabus like working principle, construction, application, use of measuring instrument and its techniques.

Course Objectives:

1. Choose suitable instrument / gauge / method of inspection for determining geometrical anddimensional measurements
2. Understand the basic concepts of metrology, various standards and methods of dimensional measurement.
3. Make use of different tools and advance instruments to measure the various parameters of screw threads, gears and surface quality
4. Analyze the quality by appropriate Quality Control Tools or technique for given application.
5. Develop an ability of problem solving and decision making by identifying and analyzing the cause for variation and recommend suitable corrective actions for quality improvement.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Bloom's Cognitive Descriptor
CO1	**Select / Choose** appropriate measuring instrument for specific application	I	Remember
CO2	**Understand** basic concepts of metrology, various standards and methods of dimensional measurement.	II	Understand
CO3	**Make use of** different tools and advance instruments for evaluating different parameters	III	Apply
CO4	**Analyze** the quality by appropriate Quality Control Tools or technique for given application.	IV	Analyze
CO5	**Develop** an ability of problem solving in quality related aspects	VI	Create

CO-PO-PSO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1		2	2											1	
CO2		2	2	2										2	
CO3	3	3	2	2	2								2	2	2
CO4	3.	2	2	2	3			2						2	
CO5	3	3	3	3	3			3						2	2

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and oneEnd Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks

ISE 1	10
MSE	30
ISE2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally lastthree modules) covered after MSE.

Course Contents:

Unit 1:--- Basics of Metrology Need of measurement, errors in measurement, and standards of measurement, Line & End, Linear measurement: slip gauges and other basic devices of linear measurements. Angular measurement: Bevel Protractor, Clinometers, Angle Dekkor, Sine bar, Angleslip gauges. Calibration & Need for Calibration. Tolerances and Gauging: Unilateral and bilateral tolerances, Limit and Fits, Types of Fits, plain gauges and gauge design (numerical treatment) , interchangeability and selective assembly.	6 **Hrs.**
Unit 2:--- Comparators & Interferometry, Advance metrology Comparators : Mechanical(Sigma, Twisted strip), Pneumatic(Differential),Electrical (LVDT). Optical – (Profile Projector) , and their applications Interferometry: Principle of Interferometry and application in checking of flatness, height. Coordinate Measuring Machine (CMM): Fundamental features of CMM – role of CMMs – types of CMM and Applications, – types of probes, Laser in Metrology, Automatic inspection system, Machine vision for online-offline inspection.	7**Hrs.**
Unit 3:--- Metrology of Thread, Gears Measurement of Thread form: Thread form errors, Measurement of Minor, Major and Effective diameter (Two Wire Method), Flank angle, pitch & pitch error Floating Carriage Micrometer (Numerical). Gear Metrology: Types of errors, Gear tooth Vernier, Chordal thickness method, Constant chord, Base tangent (Numerical), Gear Rolling Tester.	6**Hrs.**
Unit 4:--- Surface finish measurement & G.T. Surface Finish: Types of textures obtained during m/c operation, CLA(Ra), RMS, Rz assessment methods, direction of lay, texture symbols, ,instruments used in surface finish assessment. Symbol for designating surface finish, straightness, flatness, squareness, roundness on drawing Geometric dimensioning & Tolerances (GD&T) for geometric features.	6 **Hrs.**
Unit 5:--- Introduction to Quality and Quality Tools Various definitions, Concept of Quality, evolution of quality, quality of design and conformance, balance between cost of quality and value of quality, Deming's cycles & 14 Points, Juran Trilogy approach, Seven Quality Tools (basic) ,5S, Kaizen, Poka yoke, Kanban, JIT, FMECA, Zero defects, TPM. Six Sigma: DMAIC - Concept and Applications.	8 **Hrs.**
Unit 6:--- Statistical Methods in Quality Control Statistical quality control: Statistical concept, Frequency diagram, Concept of variance analysis, Control Chart for Variable (X bar & R Chart) & Attribute (P, np & C Chart) , Process capability(Indices: cp, cpk, ppk), Statistical Process Control..Inspection, stages of inspection, sampling inspection, single, double and multiple sampling plan. Operating characteristic curves, conflicting interests of consumer and producer, producer and consumers risks, AQL, LTPD.	7 **Hrs.**

Textbooks:

1. R.K. Jain, "Engineering Metrology", Khanna Publisher,
2. I.C. Gupta, "Engineering Metrology", Dhanpat Rai Publications.,
3. M. Mahajan, "Statistical Quality Control" Dhanpat Rai & Co., 2012

References:

1. N.V Raghavendra and L. Krishnamurthy, Engineering Metrology and Measurements, Oxford University Press, 2014.
2. J.F.W. Gayler and C.R. Shotbolt, "Metrology for Engineers", Cassell, 1990
3. K.W.B. Sharp, "Practical Engineering Metrology", Pitman London, 1st Edition 1973
4. R.C. Gupta, "Statistical Quality Control", Khanna Publication, 1st Edition,1978

Industrial Visit to study Latest Metrological Instruments.

Unit wise Measurable students Learning Outcomes:

1. Students will define different terms in measurement
2. Students will select proper instrument for measurement
3. Students will define terminology of limit system
4. Students will identify different types of fits
5. Students will design a gauge
6. Students will identify different types of magnification methods and comparators
7. Students will demonstrates use of various angle measuring Instruments
8. Students will demonstrates concept of Interferometry and its use in Flatness measurement
9. Students will demonstrates various parameters of surface finish
10. Students will demonstrates various methods of surface finish Measuring instruments
11. Student will measure different parameters of External thread by various measurement methods
12. Student will measure different parameter s of Gear by various measurement methods
13. Students will explain concepts of Quality and Quality Control
14. Students will explain SQC terms and its use in Quality Control
15. Students will explain Acceptance Sampling and its relevance in practical

Title of the Course: Dynamics of Machines Course Code: UMEC0503	L	T	P	Credit
	03	-	-	03

Course Pre-Requisite: Engineering Physics, Applied Mechanics, Kinematics of Machines.

Course Description:

This course is an introduction to the Dynamics and Vibrations of Lumped-Parameter models of Mechanical Systems. Topics covered include Inertia forces and Inertia torques in mechanisms. Balancing of multi-cylinder in-line engines. Gyroscopic motion: Simple theory of gyroscopic couple, gyroscopic effects in machinery, applications of gyroscopes. Fluctuation of energy and speed in machines: crank-effort and turning moment diagrams in flywheels. Free and forced vibrations of one-degree-of-freedom systems with and without viscous damping.

Course Objectives:

1. Identify the various types of gear trains used for transmission of motion and power.
2. Analyze the gyroscopic effects on vehicles, aero plane and ship.
3. Analyze the problems on balancing of rotary and reciprocating masses.
4. Perform force analysis of simple mechanisms and balancing.
5. Study basic concepts of vibration analysis.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Define various terminology related to kinematics of machine elements.	3	Applying
CO2	Identify the various mechanisms and its components.	3	Applying
CO3	Apply analytical formulae to simple mechanisms.	3	Applying
CO4	Analyze dynamics of simple mechanisms.	4	Analyze

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3														
CO2	2	2	1												
CO3	2	2	2	1	1								1	1	1
CO4		3	2	1	1	1	1	1	1	1			2	2	2

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with 60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:	
Unit 1:---Gear Trains Types of Gear trains- Simple, Compound, Reverted, Epicyclic gear train, Tabular method for finding the speeds and torques of elements in epicyclic gear train. Equivalent mass Moment of Inertia applied to gear trains.	06 **Hrs.**
Unit 2:---Gyroscope Gyroscopic couple, Spinning and Precessional motion, Gyroscopic couple and its effect on – i) Aero plane ii) Ship iii) Four-Wheeler iv) Two –Wheeler.	07 **Hrs.**
Unit 3:---Static and Dynamic force analysis Velocity and acceleration of slider crank mechanism by analytical method, Inertia force and torque, D'Alembert's principle, Dynamically equivalent system, Force analysis of reciprocating engine mechanism.	07 **Hrs.**
Unit 4:--- Balancing and Flywheel Static and Dynamic balancing of rotary and reciprocating masses. Primary and Secondary forces and couples. Balancing of Single cylinder, Multi cylinder-Inline Engines. Function of flywheel and Study of turning moment diagram.	07 **Hrs.**
Unit 5:---Free Vibrations (SDOF) Basic concepts and definitions, vibration measuring parameters- Displacement, Velocity and acceleration, Free and forced vibrations, Equivalent Springs. Types of damping. Free vibrations with and without damping (Rectilinear, Torsional & Transverse), Degree of damping. Logarithmic decrement, equivalent viscous damping, Coulomb damping.	07 **Hrs.**
Unit 6:---Forced Vibrations (SDOF) Forced vibrations with viscous damping, magnification factor, frequency response curves, vibration isolation and transmissibility, forced vibrations due to support excitation. Critical speed of shafts.	06 **Hrs.**
Textbooks: 1. Ratan S.S, "Theory of Machines", Tata McGraw Hill, New Delhi, 3rd Edition, 2011. 2. Sadhu Singh,"Theory of Machines", Pearson Education, 2nd Edition, 2009 3. H. G. Phakatkar,"Theory of Machines I", Edition 2009.Nirali Publication,5th Edition 2009. 4. Mechanical Vibrations by Grover G.K., Nemchand Publications.	

References:

1. Hamilton H Mabie and Charles F Reinholtz, (1987), "Mechanisms and Dynamics of Machinery", Fourth Edition, John-Wiley and Sons, Inc., New York.
2. Ghosh A. and Mallick A.K., (1988), "Theory of Mechanisms and Machines", Affiliated East-West Press Pvt. Ltd., New Delhi.
3. William T Thomson, Marie Dillon Dahleh and Chandramouli Padmanabhan, (2004), "Theory of Vibration with applications", Fifth Edition, Pearson Education Publishers.
4. Theory of Machines by Dr. V.P.Singh, Dhanpat Rai Publications.
5. Theory of Machines by Ballaney, Khanna Publications.
6. Mechanical Vibrations by S.S.Rao, Pearson Education Publications
7. Theory of vibrations with applications by W.T. Thomson (CBS Publications)
8. Kinematics, Dynamics and Design of Machinery by Walidron, Wiley India Publi.
9. Theory of Vibration with applications by W.T.Thomson M.D.Dahleh.C.Padmanabhan Pearson Education

Unit wise Measurable students Learning Outcomes:

1. Identify types of Gear trains
2. Explain the concepts of gyroscope
3. Evaluation of Static and Dynamic force analysis
4. Apply Balancing principles to the Reciprocating and Rotary machines.
5. Understand the fundamental concepts of vibrations.
6. Apply analytical formulae to solve vibratory problems.
7. Explain the whirling of shafts.

Title of the Course: Machine Design Course Code: UMEC0504	L	T	P	Credit
	3	-	-	3

Course Pre-Requisite:
Analysis of Mechanical Elements, Kinematics of Mechanics, Engineering Mathematics.

Course Description:
The Machine design course aims to design the mechanical elements as per the requirement to accomplish the objective of task. The design Engineer requires selecting standard components such as rolling contact bearings and sliding contact bearings. The knowledge of Machine design will enable students to understand the procedures of selection of bearings, design the mechanical components against fluctuating load. By applying the basic principles of machine design students should be able to design the Machine Elements like, Shaft, Couplings, Welded and Bolted joints.

Course Objectives:

1. To study fundamental principles in design of machine elements.
2. To learn to use of design data book for design of machine elements.
3. To learn to select machine elements from manufacturer's catalogue.
4. To design of components subjected to dynamic load and static loading.
5. To analyze the gears with respect to strength point of view.
6. To measure design parameters of mechanical systems.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Bloom's Cognitive Descriptor
CO1	Explain fundamental principles of fatigue and stress concentration in design of components	II	Understanding
CO2	Identify parameters required for design of mechanical Components.	III	Applying
CO3	Determine the design parameters of mechanical components.	V	Evaluating
CO4	Design of power transmission elements.	VI	Creating

CO-PO-PSO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	3	3	-	-	-	-	-	--	-	-	2	2	-
CO2	2	2	3	3	-	-	-	-	-	-	-	-	2	2	-
CO3	2	2	3	3	-	-	-	-	-	-	-	-	2	2	-
CO4	2	3	2	2	-	-	-	-	1	-	2	-	2	2	-

Assessments :
Teacher Assessment:
Two components of in Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10

MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/case study etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with 60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:- Theories of failure and Design against fluctuating load. Introduction on material designation as per standards, Theories of failure, Stress concentration, fluctuating stresses, S-N. diagram under fatigue load, endurance limit, notch sensitivity, endurance strength- modifying factors, design for finite and infinite life under reversed stresses, Soderberg and Goodman diagrams, modified Goodman diagram, fatigue design for components under combined stresses.	**07 Hrs.**
Unit 2:--- Design of Shafts, Keys and Couplings Design of shafts on the basis of strength, Torsional rigidity and A.S.M.E. code, Design of keys and Splines, Design of Muff and Flange Couplings.	**06 Hrs.**
Unit 3: Design of bearings Classification of bearings, static and dynamic load capacities, Stribeck's equation, equivalent bearing load, load- life relationship, Bearing life, Selection of bearing from manufactures catalogue. Ball and Roller bearing, Design for variable load and speed, Bearings with probability of survival other than 90%. Lubrication and mountings, dismounting and preloading of bearings, Introduction on Sliding contact bearing.	**07Hrs.**
Unit 4: Design of Spur and Helical gear **i) Spur Gear:** Gear tooth loads, No. of teeth, face width, strength of gear teeth, static beam strength (Lewis equation), dynamic tooth load, wear strength (Bucking ham's equation), Estimation of module based on beam strength and wear strength. Methods of gear lubrication. **ii) Helical Gears:** Terminology, Formative number of teeth in helical gears, force analysis, beam & wear strength of helical gears, effective load & design of helical gear.	**07Hrs.**
Unit 5:Design of bevel and worm gear **i) Bevel Gear :** Types of bevel gears, Straight tooth bevel gear terminology and geometrical relations. Guideline for selection of dimensions and minimum number of teeth, Force analysis, Beam and wear strength, Dynamic tooth load, Design of straight tooth bevel gears based on beam and wear strength.	**07 Hrs.**

ii) Worm and worm wheel : Terminology and geometrical relations. Standard dimensions and recommendation of worm gearing, Force analysis, Friction, Efficiency of worm gear drive, Design of worm drive as per IS 7443-1974 based on beam strength and wear strength rating, Thermal consideration in worm drive.	
Unit 6:--- Design of Bolted & Welded Joints Design of bolted joints subjected to Eccentric Loading- 1) In a plane containing bolts, 2) Parallel to axis of bolt, 3) Perpendicular to the axis of bolt. Welding symbols, Stresses in butt and fillet welds, Strength of butt, parallel and transverse fillet welds, Eccentric load in plane of welds, Welded joints subjected to bending moment.	06 **Hrs.**

Textbooks:

1. Design of Machine Elements, Bhandari V. B Tata McGraw Hill New edition
2. Mechanical Engineering Design, Shigley J.E. and Mischke C.R. – McGraw Hill Publ. Co. Ltd.
3. Machine Design, R.K.Jain, Khanna Publication.
4. Machine Design, Pandya Shah, Charotar Publication.
5. Machine Design, U.C.Jindal, Pearson Education.
6. Introduction to Machine design, V.B. Bhandari, Tata McGraw Hill Publication, 2nd Edition.

References:

1. Machine Design – Black P.H. and O. Eugene Adams – McGraw Hill Book Co. Ltd.
2. Mechanical Design of Machine", Maleev V.L., Hartman J.B, CBS Pub. & Distributors,
3. Design Data Handbook – P.S.G. College of Technology, Coimbatore.
4. Hall A.S.; Holowenko A.R. and Laughlin H.G. – "Theory and Problems of Machine Design" Schaum's outline series.
5. Machine Design, Hall, Holowenko Laughlin, Tata McGraw Hill Pub. Schaums Outline Series.
6. Design of Machine Element, M.F.Spotts, Pearson Education Publication, 6th Edition.
7. Machine Component Design, Robert C. Juvniall, Willey Ltd, 5th Edition.
8. Mechanical Design of Machine Elements and Machines, Jack A Collis Henry Busby, George StaabWiley ltd., 2nd Edition.
9. Machine Design, P. Kannaiah, Scitech Publication, 2nd Edition.
10. Design Data Book, Mahadevan, CBS Publishers and Distributors Pvt Ltd, 4th Edition.

Unit wise Measurable students Learning Outcomes:

1. Student should be able to know basic principles of design of mechanical component against fluctuatingload.
2. Student should be able to design of solid, hollow shafts, key & couplings.
3. Student should be able to select and recommend suitable bearing for particular application
4. Student should be able to design spur and helical gear
5. Student should be able to design bevel and worm gear.
6. Student should be able to design of bolted joints & welded joints.

Title of the Course: Numerical Methods	L	T	P	Credit
Course Code:UMEE0511	2	1	-	0

Course Pre-Requisite:

Engineering Mathematics-I, Engineering Mathematics-II, Engineering Mathematics-III, Numerical Methods in Engineering

Course Description:

The course is aimed to provide elementary knowledge of numerical methods and statistical techniques and enable students to apply various tools and techniques to solve problems in mechanical engineering. The subject provides the students with a strong background on numerical approximation strategies and a basic knowledge on the theory that supports numerical algorithms. The course starts with introduction of numerical methods and its applicability in mechanical engineering with an introduction to basic computation using C++ or MATLAB. It covers the concepts of solution techniques of linear and non-linear equations and systems of equations. Differentiation and integration using numerical methods are covered. Application of different initial value and boundary value problems in mechanical engineering using finite difference method is taught. An introduction to solution of partial differential equation and finite element method is also covered.

Course Objectives:

1. To provide the student with general techniques to formulate, model and mathematically solve advanced design engineering problems.
2. To introduce the students with basic numerical methods and software tools for solving design engineering problems.
3. To enable the students to use appropriate analytical and computational tools to investigate design problems.
4. To prepare students to outline the physical systems and formulate mathematical models for them.
5. To make students to solve differential equations using numerical techniques and transform technique.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		level	Descriptor
CO1	Solve design engineering problems by using appropriate numerical methods	2	Understanding
CO2	Conduct experiments and analyze the numerical data.	2	Understanding
CO3	Interpret interpolation, statistical data and approximation for design engineering problems.	2	Understanding
CO4	Design machines, systems, and projects required for industry.	3	Applying

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2			1										
CO2		3	1		1									1	
CO3		2	1		1									1	
CO4		1	2		1									1	

Assessments :

Teacher Assessment:

End Semester Examination (ESE) for 100 marks

Assessment	Marks
ESE	100

Course Contents:	
Unit 1:--- **Errors:** Introduction of Numerical error and accuracy, Types of errors, Rules for estimate errors, Error Analysis, accuracy of numerical results. **Roots of Equation** Bisection method, Regula falsi method Newton Raphson's, Multiple Roots, Iteration system of non- linear Equations, Secant method.	**7 Hrs.**
Unit 2:--- Linear Algebraic Equation: Gauss Elimination Method- Naïve Gauss Elimination, Pitfalls of Elimination, Techniques of improving solutions, Gauss- Jordan method Matrix Invention- LU decomposition, Gauss Seidel, Jacobi Iteration method, System of linear equations	**5 Hrs.**
Unit 3:---A. Curve Fitting: Least Square Regression – Linear regression, Polynomial Regression Interpolation – Newton's divided difference, Interpolating polynomial, Lagrange's interpolating polynomial. B. **Statistics:** Mean and standard deviation	**8 Hrs.**
Unit 4:--- Numerical Differentiation and Integration Numerical Integration (Simpsons, Trapezoidal and Gauss Quadrature methods). Solution of Non linear equations, Applications of numerical techniques. Integration of Equation: Romberg's Integration and Gauss Quadrature. Numerical differentiation, Differentiation formulae, Derivation of unequally spaced data, Forward difference, Central difference, Backward difference Problems based on engineering applications.	**7 Hrs.**

Unit 5:--- Ordinary Differential Equation: Taylor's series method, Picard's Method, Runge-Kutta method, Euler's Method, Improved polygon method, System of equation Boundary value and Eigen value problem, Finite Difference Method, Eigen value problem based on polynomial method, Determination of Eigen values by Power method, Problems based on engineering applications.	**6 Hrs.**
Unit 6:--- Partial Differential Equation: Finite Difference – Elliptic equation, Laplace's equation, Liebmen's Method, Secondary variables, Boundary condition. Problems based on engineering application. Finite Difference- Parabolic Equation , Explicit Method, Introduction of MATLAB, Mechanical Engineering Problem solving approach by using MATLAB.	**7 Hrs.**

Module wise Measurable Students Learning Outcomes :

Obtain root of given function/polynomial using numerical methods.
Solve linear simultaneous equations using numerical methods.
Analyze the data and apply numerical methods to fit a curve on the data.
Solve the complex differential and integral equations in mechanical engineering.
Solve the ODE applicable for mechanical engineering using numerical methods.
Solve the PDE applicable for mechanical engineering using numerical methods.

Textbooks:

1. Dr. B. S.Grewal, "Numerical Methods", Khanna Publishers, New Delhi.
2. E. Balguruswamy, "Numerical Methods", Tata Mcgraw Hill Publication Company Ltd.
3. Steven C. Chapra, "*Numerical Methods for Engineers*", Tata McGraw Hill Publications, New Delhi
4. "Numerical Methods", S.Arumugam, A. Thangapandi Isaac and A.Somasundaram, Scitech Publications India Pvt.Ltd.,Chennai.

References Books:

1. J.N. Kapoor, "Mathematical Modeling",New Age Mumbai, first Edition,2005. Kreyszig, "Advanced Mathematics",LaurieRosatone, USA.
2. S.C. Chapra, "Applied Numerical Methods with MATLAB for Engineers and Scientists", Tata McGraw Hill Education Pvt. Ltd., New Delhi
3. Sigiresu S Rao, "Engineering Optimization",New Age International Publisher.
4. R. L. Burden and J. D. Faires, "Numerical Analysis Theory and Applications", Cengage Learning India Pvt. Ltd., New Delhi

TERM WORK:

Students are expected to solve at least two problems on each method by appropriate numerical method on each unit.
Students are expected to develop computer programs on each unit. ((Algorithm, Flow charts, Computer code, problem with analytical treatment)

Title of the Course: Advance Energy Technology Course Code:UMEE0512	L	T	P	Credit
	03	-		03

Course Pre-Requisite: Basic Physics, Chemistry, Basic Mechanical Engg

Course Description : The course will cover following topics Solar , wind ,biomass ,tidal energy and prospective , efficient use of primary energy sources, different power plants, Energy management ..

Course Objectives:

1. Acquire the knowledge of renewable sources of energy and utilization.
2. Enable the student to estimate the potential of energy sources.
3. Study various power stations , Performance and economic analysis
4. Understand the new trends in power and energy sectors

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Demonstrate need of different energy sources and their importance	II	Understanding
CO2	Make use of Renewable energy for power generation	III	Applying
CO3	Analyze the utilization of solar, wind energy etc	IV	Analyazing

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3						2						2		
CO2	3						2						2		
CO3		3					2					2			

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:--- Introduction to Renewable Energy sources	**6 Hrs.**
-Environmental degradation due to energy production and utilization, primary and secondary pollution-air, thermal and water, depletion of ozone layer, global warming, biological damage due to environmental degradation, pollution due to thermal power stations and their control, Energy management and marketing, Energy audit .	

Unit 2:--- Introduction to Solar Energy , Solar potential, Solar radiation spectrum, Solar radiation geometry (Numerical on angle of incidence only), Solar radiation data, ,Solar Collectors (Flat plate, evacuated tube, Cylindrical parabolic, Concentrating paraboloid),Graphical representation of efficiency of various Collectors , Testing of Solar flat plate collectors – BIS code (No numerical), Thermal Energy storage (Introduction and types)	**7 Hrs.**
Unit 3:--- Photovoltaic cell Operating Principle of Photovoltaic cell concepts, Photo-cell materials, Cell module array, Series and parallel connections, Maximum power point tracking, Design of standalone system with battery and AC or DC load (Descriptive Treatment), Applications, Introduction, Principle and operation of fuel cells, classification and types of fuel cell. Fuel for fuel cells, Application of fuel cells.	**7 Hrs.**
Unit 4:---Wind Energy Wind parameters and wind data, Power from wind, Site selection, Wind energy conversion systems and their classification, Construction and working of typical wind mill, Introduction to OTEC and Hybrid systems (Diesel-PV, Wind-PV Biomass-Diesel systems)	**6Hrs.**
Unit 5:--- Other Renewable Energy Sources Renewable Energy Sources Biomass: as a source of energy, Classification of biomass, Biomass conversion processes, Biogas plant and its components, Types of biogas plants. Geothermal Energy: Resources, types of wells, methods of harnessing the energy, potential in India. Ocean Energy: Ocean Thermal Energy Conversion, Principles utilization, setting of Ocean Thermal Energy Conversion plants, Comparison with normal thermal power cycles. Tidal and wave energy: Potential and conversion techniques, mini-hydel power plants, and their economics	**8 Hrs.**
Unit 6:--- Energy conservationa and Energy Management Energy efficiency and energy conservation in boilers, furnaces, HVAC, motors, compressors, etc. solar passive architectural techniques and Green buildings, Energy Conservation and its Importance; Energy Strategy for the Future; The Energy Conservation Act, 2001 and its Feature, Energy Management .	**6 Hrs.**

Text Books –

1. Non-conventional energy sources by G.D. Rai, Khanna Publishers
2. Solar Energy: Principles of Thermal Collection and Storage by S,P Sukhatme, Tata McGraw Hill
3. Solar Engineering of Thermal processes, J.A.Duffie and W.A.Beckman, 2ndedition, John Wiley, New York, 1991.
4. Handbook of Biogas Technology, Prattek Shilpkar & Deepti Shilpkar

References:

1. Fuel Cells by Bockris and Srinivasan; McGraw Hill.
2. Solar Energy: Fundamentals and Applications by H.P. Garg& Jai Prakash, Tata McGraw Hill.
3. Wind Power Technology, Joshua Earnest, PHI Learning, 2014
4. Non Conventional Energy Resources by S. Hasan Saeed and D. K. Sharma, S. K. Kataria& Sons.
5. Renewable Energy Sources, J W Twidell& Anthony D. Weir. ELBS Pub.
6. Energy Conversion Systems, R D Begamudre, New Age International (P) Ltd., Publishers,

New Delhi ,2000.
7. Principles of Solar Engineering, D.Y.Goswami, F.Kreith and J.F.Kreider, Taylor and Francis,Philadelphia, 2000..

Unit wise Measurable students Learning Outcomes:
After completion of unit , students are able to

1. Explain importance of renewable energy
2. Explain fundamental knowledge of Solar Energy
3. Explain working principle of photovoltaic cell
4. Explain fundamental knowledge of Wind Energy
5. Explain fundamental knowledge of Biomass, Wave,Tidal, Ocean, Energy
6. Explain fundamental knowledge of Energy conservation and management

Title of the Course: Safety and Maintenance Engineering [Program Elective-I]	**L**	**T**	**P**	**C**
Course Code: UMEE0513	**3**	**-**	**-**	**3**

Teaching Scheme: 3 Hrs per week

Course Prerequisite:
Preliminary knowledge of various types of machines and introduction to functions of management

Course Description:
This course aims to impart knowledge of maintenance of equipment in industries. In order to avoid accidents and to survive and progress proper maintenance of equipment is necessary to be done in industry. This course provides information about wear, corrosion, lubrication, preventive maintenance; decision tree to diagnose faults, important provisions of factory act, alignment of equipment etc. This course also provides basic knowledge and skills regarding maintenance problems, their causes and remedies in industries.

Course Objectives:

1) To understand safety engineering aspects in industry.
2) To educate and train for safety in order to prevent causes and cost of accident.
3) To understand the principles, functions and practices adapted in industry for the successful management of maintenance activities.
4) To understand the different maintenance categories like Preventive maintenance, condition monitoring and repair of machine elements.

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	**Bloom's Cognitive**	
		Level	**Descriptor**
CO1	**Explain** the importance of safety	II	Understanding
CO2	**Understand** various factories acts and rules related to employee's safety	II	Understanding
CO3	**Make use of** preventive maintenance to carry out plant maintenance	III	Applying
CO4	**Identify** and avoid accidental hazards	III	Applying
CO5	**Choose** appropriate method for reconditioning and retrofitting process of machine elements	V	Evaluating

	Course Outcome - Program Outcome Attainment Matrix														
	PO's												***PSO's***		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	***1***	***2***	***3***
CO1	**2**	**2**													
CO2	**2**	**2**													
CO3	**1**		**3**						**2**					***2***	
C04	**1**		**3**											***2***	
CO5	**2**		**2**	**3**										***2***	

Assessments :
Teacher Assessment:
Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	**Marks**
ISE 1	**10**
ISE 2	**10**
MSE	**30**
ESE	**50**

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with 60-70% weightage for course content (normally last three modules) covered after MSE

Unit 1: Introduction to the development of industrial safety and management:	**5 Hr**

History and development of Industrial safety, Implementation of factories act, Formation of various councils, Safety and productivity, Accident, Injury, Hazard, Unsafe act, Unsafe Condition, Dangerous Occurrence, Reportable accidents. Safety organization- objectives, types, functions, Role of management, supervisors, workmen, unions, government and voluntary agencies in safety, Safety policy. Safety Officer-responsibilities, Safety analysis, PHA, HAZOP methodology

Unit 2: Accident preventions, PPE, Safe workplace design: **8 Hr**

Personal protective equipment (PPE), Working in hot environment like casting, forging, rolling, sheet metal and other metalworking processes, Safety education and training, First aid, Firefighting equipment, Accident reporting, Investigations, Industrial psychology in accident prevention, Safety trials. Housekeeping,5S of housekeeping, confined space entry, Safety hazards in machines, Point-of-Operation, Principle of machine guarding , Designing safety features in machine and equipment, types of guards and devices, Safe layout for process industries, engineering industry, thermal power stations, metal powders manufacturing, Emergency response preparedness, Poka-Yoke for safe design and operation,

Unit 3:Safety Acts **5 Hr**

Introduction to factory act, Indian boiler (amendments) act, pesticides act, explosives act ,workman compensation act, electricity act, Hazardous waste management, E waste rules,industrial hygiene, occupational safety, diseases prevention, ergonomics, occupational diseases, stress, fatigue, health, safety and the physical environment, engineering methods of controlling chemical hazards, control of industrial noise and protection against it, Introduction to OSHA [Occupational Safety and Health Administration], NSCI safety awards scheme - an overview. Introduction to SIL (safety integrity level),types of hazardous waste and their disposal,

Unit 4: Principles of Maintenance planning: **7 Hr**

Basic Principles of maintenance planning-Objectives and principles of planned maintenance activity. Safety Officer's Role in Maintenance Work, Importance and benefits of sound Maintenance systems, Reliability and machine availability, Equipment Life cycle, Measures for Maintenance Performance: Equipments breakdowns, Mean Time Between Failures, Mean Time To Repair, Factors of availability, Maintenance organization, Maintenance economics

Unit 5: Maintenance policies and preventive maintenance: **7 Hr**

Maintenance categories- Comparative merits of each category- Preventive maintenance, Maintenance schedules: Repair cycle, Principles and methods of lubrication, Fault Tree Analysis, Total Productive Maintenance: Methodology and Implementation

Unit 6: Condition Monitoring: **7 Hr**

Condition Monitoring: Cost comparison with and without Condition Monitoring, On-load testing and off load. Methods and instruments for Condition Monitoring, Temperature sensitive tapes, Pistol thermometers, Infrared thermography, Lubrication oil analysis, wear-debris analysis, Noise Vibration and harshness analysis of machines, Applications of IOT in condition monitoring

Text Books:

1) Srivastava, S.K., "Industrial Maintenance Management", S. Chand and Co.
2) Bhattacharya, S.N., "Installation, Servicing and Maintenance", S. Chand and Co.
3) Willie Hammer, "Occupational Safety Management and Engineering", Prentice Hall

Reference Books:

1) White, E.N., "Maintenance Planning", Documentation, Gower Press
2) Garg, M.R., "Industrial Maintenance", S. Chand and Co.
3) Higgins, L.R., "Maintenance Engineering Hand book", 5th Edition, McGraw Hill
4) Armstrong, "Condition Monitoring", BSIRSA
5) Davies, "Handbook of Condition Monitoring", Chapman and Hall
6) Ray Asfahl, C., "Industrial Safety and Health Management", 5th Edition, Prentice Hall
7) S.C.Mishra, "Reliability and Maintenance Engineering", New Age Publishing house
8) Engineering Systems Reliability, Safety, and Maintenance An Integrated Approach, B.S. Dhillon, CRC Press Taylor & Francis Group
9) Fundamentals of Process Safety Engineering, Samarendra Kumar Biswas Umesh Mathur Swapan Kumar Hazra, CRC Press Taylor & Francis Group
10) Health and Safety: Risk Management, Fifth edition ,Dr.Tony Boyle.

Title of the Course: **Smart Materials** **Course Code: UMEE0514**	**L**	**T**	**P**	**Credit**
	3	0	0	**3**

Course Pre-Requisite: Chemistry, Physics.

Course Description:

The content of this course covers basics of different smart materials, their potential use in engineering fields. This course is also useful in helping students to learn the use of smart materials to automate the different tasks at micro/nano level workspace and to develop micro/nano system. It will also impart knowledge of nanomaterials, its synthesis and nanocomposites with tailored properties which can be used for several applications.

Course Objectives:

1. To study the working principles of various smart materials.
2. To identify applicability of various smart materials as actuator and sensor.
3. To study advances in smart materials.

Course Outcomes:

CO	On completion of the course, the student will have the ability to:	Bloom's Level
CO1	Classify and select different types of smart materials	1,2
CO2	Comprehend Important Concepts and principles of Smart Materials	2
CO3	Synthesis, sensing and actuation of Piezoelectric Materials, Magneto strictive Materials, Shape Memory Alloys, Electroactive Polymers	5,6
CO4	Synthesis, sensing and actuation of Ferrofluids and Magneto rheological Fluids, Soft Matter, Carbon Nanotubes and Carbon nanostructures, Thermoelectric Materials	5,6
CO5	Classify and select Smart Materials for Energy Applications: Materials used for energy storage	3,4
CO6	Classify and select Composite Materials, Nano Composite Materials	3,4

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	-	-	-	1	-	1	-	-	-	-	-	1	-	-
CO2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	2	-	-	-	-	-	-	-	-	-	-	2	-
CO4	-	-	2	2	-	-	-	-	-	-	-	-	-	2	-
CO4	-	-	3	2	-	-	-	-	-	-	-	-	-	-	-

Assessment Scheme:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weightage respectively.

Assessment Component	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and **ISE 2** are based on Assignment/Declared test/Quiz/Seminar/Group discussions/presentation, etc.
MSE is based on 50% of course content (first three units).
ESE is based on 100% course content with 60-70% weightage for course content (last three units) covered after MSE.

Course Contents		
Unit No.	**Unit Title and Contents**	**Hours**
1	**Introduction to Smart Materials:** Overview of the different types of Smart Materials, Smart materials used in structures, smart material for sensors, actuators controls, memory and energy storage and their inter- relationships, concept of High bandwidth- low strain generating materials (HBLS), and Low Bandwidth High Strain Generating Materials (LBHS), Nano Composite Materials.	7
2	**Important Concepts of Smart Materials:** Artificial skins, artificial muscles, biomimetic materials, materials with tuneable responses, non- linear properties, self-healing materials, adaptive structures, self-replicating materials/structures, self-assembly, inch worm devices, hysteresis, integrated sensing and actuation.	8
3	**Overview of the following materials with focus on synthesis, constitutive/governing relationships, strengths and weaknesses, and applications (both sensing and actuation etc).** 1. Piezoelectric Materials 2. Magneto strictive Materials 3. Shape Memory Alloys 4. Electroactive Polymers	6
4	**Overview of the following materials with focus on synthesis, strengths and weaknesses, and applications** 1. Ferrofluids and Magneto rheological Fluids and applications in dampers 2. Soft Matter and its applications as smart skins, smart textiles etc 3. Carbon Nanotubes and Carbon nanostructures and its applications 4. Thermoelectric Materials and Peltier devices.	6
5	**Smart Materials for Energy Applications:** Materials used for energy storage, Hydrogen Storage Materials, Energy harvesting, Energy scavenging from vibrations.	6
6	**Manufacturing techniques for smart materials:** micromanufacturing, high resolution lithography, LIGA process, Generative manufacturing processes such as STL, SLS, SPB, BPM, LOM, SGC, FDM, BIS, BPM, Self-assembly process, Ion beam processes,	7

Textbooks:

1. Inderjit Chopra and Jayant Sirohi, *Smart Structures Theory, Cambridge Press.*
2. V.K. Varadan, K.J. Vinay, and S. Gopalakrishnan, *Smart Materials Systems and MEMS Design and Development Methodologies, John Wiley and Sons.*
3. G. K. Narula, K. S. Narula, V. K. Gupta, "Material Science", TMH, 2007
4. Pradeep T, "Nano: The Essentials", McGraw Hill Publishing Co. Ltd., 2007
5. William D. Callister, Jr. "Materials Science and Engineering An Introduction", John Wiley& Sons, Inc.7th Edition
6. G. Gautschi, "Piezoelectric Sensorics: Force, Strain, Pressure, Acceleration and Acoustic Emission Sensors, Materials and Amplifiers", Springer, Berlin; New York, 2002 (ISBN:3540422595)
7. K. Uchino, "Piezoelectric Actuators and Ultrasonic Motors", Kluwer Academic Publishers, Boston, 1997 (ISBN: 0792398114)
8. A.V. Srinivasan, "Smart Structures: Analysis and Design", Cambridge University Press,Cambridge; New York, 2001 (ISBN: 0521650267)
9. G. Engdahl, "Handbook of Giant Magneto strictive Materials", Academic Press, San Diego, Calif.; London, 2000 (ISBN: 012238640X)
10. K. Otsuka and C.M. Wayman, "Shape Memory Materials", Cambridge University Press, Cambridge; New York, 1998 (ISBN: 052144487X)
11. Eric Udd, "Fibre Optic Sensors: An Introduction for Engineers and Scientists", John Wiley & Sons, New York, 1991 (ISBN: 0471830070)
12. André Preumont, "Vibration Control of Active Structures: An Introduction", 2nd Edition, Kluwer Academic Publishers, Dordrecht; Boston, 2002 (ISBN: 1402004966)
13. HojjatAdeli, "Control, Optimization, and Smart Structures: High-Performance Bridges and Buildings of the Future", John Wiley, New York, 1999 (ISBN: 047135094X)
14. T.T. Soong, "Passive Energy Dissipation Systems in Structural Engineering", Wiley, Chichester; New York, 1997 (ISBN: 0471968218)
15. "Shape memory materials",Edited By- K. Otsuka and C M Wayman, Cambridge Univ.Press
16. "Shape memory polymers and multifunctional composites" Edited by JinsongLeng andShanyi Du,CRC Press.
17. Anke Krueger, "Carbon materials and nano technology", Wiley – VCH
18. M.V. Gandhi and B.S. Thompson, "Smart Materials and Structures", Chapman & Hall, London; New York, 1992 (ISBN: 0412370107
19. Mel Scwartz, "Encyclopedia of Smart Materials Vol. I and II", John Wiley & Sons
20. SenolUtku, "Theory of Adaptive Structures : Incorporating Intelligence into Engineered Products", CRC Press (1998), ISBN: 9780849374319.

Reference Books:

1. Ralph C. Smith, *Smart Material Systems: Model Development, Frontier in Applied Mathematics.*
2. Callister's Materials Science and Engineering.
3. Materials Science And Engineering: An Introduction, William D. Callister Jr., David G. Rethwisch.
4. Handbook of Polymer and Ceramic Nanotechnology, Springer.
5. Nanomaterials: Synthesis, Characterization, and Applications, Sabu Thomas.
6. Nanomaterials synthesis and applications 1st Edition- May 29, 2019.

Additional Resources:

NPTEL, MIT Video Lectures, Web Resources etc.

Title of the Course: Industrial Product Design **Course Code:** UMEE0515	**L** **3**	**T** **-**	**P** **-**	**Credit** **3**

Course Pre-Requisite:
Manufacturing Processes, Machine Drawing and Computer Aided Drafting, Manufacturing Engineering

Course Description: The course is focused on new product development process through innovative ideas, screening of such ideas, feasibility study and building reliable product by gathering needs from the consumers. This course motivates and educates students to develop new products for betterment of society. This course is also useful for young entrepreneurs for converting their ideas into commercial product through systematic product development procedure.

Course Objectives:

1. To prepare students to create and execute design solutions for problems of form, usability, physical ergonomics, marketing, brand development, and sales of industrial products.
2. To educate students to conceptualize and evaluate ideas to create new reliable products.
3. To introduce students to product architecture.
4. To estimate costing for a new product.

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive level	Descriptor
CO1	Demonstrate the knowledge of indentifying customer needs for successful product development through Market research and survey.	2	Understand
CO2	Develop the knowledge of product specifications through concept and apply knowledge of integration of design aspects like product architecture, ergonomics, aesthetics, reliability and product data management.	3	Apply
CO3	Estimate cost of new product by considering various components of the costs and Explain importance of designing the product using design for X methodology.	5, 2	Evaluate Understand
CO4	Identify the importance of Personal Protective Equipments for Industrial safety.	3	Apply

CO-PO Mapping:

CO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**PSO1**	**PSO2**	**PSO3**
CO1	3														
CO2	3														
CO3	3	3											3		2
CO4		2		2									2		2

Assessments :
Teacher Assessment:
Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1: --- Introduction Challenges of product development, Identify customer needs, Successful product development, Quality aspect of product design, Market Research, Survey.	6 **Hrs.**
Unit 2: --- Product Development Process and Planning Innovation and Creativity in Product Design, Product Planning Processes, Product specifications: Process of setting specifications. (Concept Generation–Selection–Testing).	7 **Hrs.**
Unit 3: --- Product Architecture Product Architecture: Implication of architecture, Establishing the architecture, Related system level design issue, Product Data Management, Use of Computerized Data Management and `Process, Industrial Design: Overview. **Reliability of Product:** Fault Tree Analysis (FTA), Debugging Techniques, Failure Mode and Effect Analysis (FMEA), Different product reliability improvement techniques.	7 **Hrs.**
Unit 4: --- Design for X Methodology Rules, guidelines, and methodologies along the product life cycle phases: Development phase, Production phase, Use phase, Disposal phase, Concurrent Engineering. **Product Costing:** Different costs, Pre-requisites for cost accounting, Volume-Varity matrix and its impact on product costing, Value engineering.	6 **Hrs.**
Unit 5: --- Aesthetics: Aesthetic Considerations, Visual Effects of Form and Colour in Product Design. **Ergonomics:** Ergonomics and product design and automated systems, Anthropomorphic data and its applications in ergonomic design, Limitations of Anthropomorphic data, General approach to the Man-Machine Relationship - Workstation Design and environment (working position and posture). **Control, Displays and User Interfaces:** Configurations and sizes of various Control, Displays and User Interfaces, Design of instruments, controls, displays and user interfaces.	9 **Hrs.**
Unit 6: --- Industrial Safety: Personal protective Equipment and Environment Control Prevention and specific safety measures for manufacturing and processing industry and chemical industry. **Introduction to Internet of Things (IoT) and Industry 4.0-** Applications and Advantages	5 **Hrs.**

Textbooks:

1. "Product Design and Development", Karl T. Ulrich, Steven G. Eppinger; Irwin Tata McGraw Hill, 3rd Edition.
2. "Product Design and Manufacturing",A.C. Chitale and R.C. Gupta, Prentice Hall of India, 3rd Edition.
3. "Product Design",Otto and Wood, Pearson education.
4. "Human Factor Engineering", L P Singh , Galgotia Publication Pvt.Ltd, 1st Edition.

References:

1. "Introduction to Ergonomics", R.C. Bridger, Tata McGraw Hill Publication.
2. "New Product Development", Tim Jones, Butterworth, Heinemann, Oxford, (1997).
3. "Industrial Design for Engineers",Mayall W.H, London, Hiffee books Ltd.

Title of the Course: Tribology Course Code:UMEE0516	L	T	P	Credit
	3	-	-	3

Course Pre-Requisite: Engineering Mathematics, Fluid Mechanics, Machine Design, Manufacturing Process

Course Description: Tribology is the study of friction, wear and lubrication, and design of Tribological Components, science of interacting surfaces in relative motion.

Course Objectives: After successful completion of this course, students will be able-

1. To Apply the basic theories of friction, wear and lubrications about frictional behavior commonly encountered sliding surfaces
2. To Select suitable/proper grade lubricant for specific application.
3. To know about properties of lubricants, modes of lubrication, additives etc.
4. To select suitable material combination for tribological contact.
5. To suggest an explanation to the cause of tribological failures.
6. To design bearing, friction, wear test rig for laboratory purposes.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Explain industrial and practical objectives of tribology Considering parameters of tribology triangle.	2	Understanding
CO2	Explain mechanisms of friction and wear for metals, alloys, Ceramics and polymers.	2	Understanding
CO3	Illustrate different types of lubrication system and methods.	2	Understanding
CO4	Apply friction/lubrication mechanism to the practical engineering problem.	3	Applying

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1										2		
CO2	2	2													
CO3	3	2	2	2											
CO4	2	1	2	2											

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:---INTRODUCTION OF TRIBOLOGY Tribology definition, Need of Tribology, Tribology in design, Tribology in industry (Maintenance), Lubrication- Definition, Lubricant properties, Viscosity, its measurements- Numerical, basic modes of lubrication, types of lubricants, Standard Grades of lubricants, selection of lubricants, commonly used lubricants and Hazards, Recycling of used oil, Disposal of used oil, bearing materials, Fundamentals of surface engineering, Green Tribology, Bearing Terminology-Types of Sliding contact, rolling contact bearings.	08 **Hrs.**
Unit 2:---FRICTION Introduction, Laws of friction, kinds of friction, causes of friction, area of contact, friction measurement, theories of friction.	06 **Hrs.**
Unit 3:---WEAR Types of wear, various factors affecting wear, measurement of wear, theories of wear,	06 **Hrs.**

Wear debris analysis; Wear reduction methods.	
Unit 4:-- HYDRODYNAMIC LUBRICATION Theory of hydrodynamic lubrication, mechanism of pressure development in an oil film. Two dimensional Reynolds equation, Petroff's equation, pressure distribution in journal bearings - long & short, Load Carrying capacity, Somerfield number and its importance-Numerical. Introduction to Hydrodynamic Thrust Bearing	07 **Hrs.**
Unit 5:-- HYDROSTATIC LUBRICATION Introduction to hydrostatic lubrication, hydrostatic step bearing, load carrying capacity and oil flow through the hydrostatic step bearing- Numerical. Hydrostatic squeeze film : basic concept, circular and rectangular plate approaching a plane-Numerical	06 **Hrs.**
Unit 6:--- DIAGNOSTIC MAINTENANCE AND CONDITION MONITORING Types of maintenance; Preventive and corrective Maintenance; Condition Based Maintenance and Condition Monitoring; Cost effectiveness. Different condition monitoring Techniques; Visual, performance, fluid and vibration monitoring. Fluid condition and particle monitoring; Fluid degradation and its identification methods; Chemical tests, infrared spectroscopy, calorimeter. Wear debris analysis; SOAP, Ferrography and other spectrometric analysis techniques for wear rate evaluation and interpretation. Vibration monitoring methods; Vibration data collection; Techniques; Instruments; Transducers; Commonly witnessed machinery faults diagnosed by vibration analysis.	07 **Hrs.**

Teaching assessment of Tutorials will be based on the completion of following assignments

Assignment on Introduction of Tribology.
Assignment on Friction.
Assignment on Wear.
Assignment on Hydrodynamic Lubrication.
Assignment on Hydrostatic Lubrication.
Assignment on condition monitoring Techniques.

Textbooks:

1. Engineering Tribology– Prasanta Sahoo – Prentice Hall of India Pvt. Ltd., New Delhi, 2005.
2. Fundamentals of Tribology – S.K. Basu, S.N. Sengupta, B.B. Ahuja – PHI Learning Pvt. Ltd.,2010.
3. Tribology in Industries – S.K. Shrivastava – S. Chand & Company Ltd., New Delhi, 2001
4. Bearing Design in Machinery, Engineering Tribology and Lubrication - A. Harnoy- Marcel Dekker Inc., 2003

References:

1. Cameron A., Basic Lubrication Theory, Wiley Eastern Ltd.
2. Bharat Bhushan, Principles and Applications of Tribology 2nd Edition, Wiley India
3. Mujumdar B. C.,Introduction to Tribology and Bearings, S. Chand and Company Ltd. New Delhi.
4. Fuller D. D.,Theory and Practice of Lubrication for Engineers, John Wiley and Sons.
5. Halling J.,Principles of Tribology‖, McMillan Press Ltd.
6. Bhushan B. and Gupta B. K.,Handbook of Tribology: Material, Coatings and Surface Treatments, McGraw Hill Ltd.
7. Davis J.,Surface Engineering for Corrosion and Wear Resistance, Woodhead Publishing, 2001.
8. Tadausz Burakowski,Surface Engineering of Metals: Principles, Equipments and Technologies, Taylor and Francis.
9.Tribology in machine design- By -T. A. Stolarski
10.Tribology & design-edited by M. Hadfield, C. A. Brebbia, J. Seabra
11.Tribological Design of Machine Elements by D. Dowson , C.M. Taylor, M. Godet, D. Berthe

Unit wise Measurable students Learning Outcomes:

1. Summarize industrial and practical aspects of tribology.
2. Explain mechanisms of friction for metals, alloys, ceramics and polymers.
3. Illustrate various types of wear and wear measurement equipment.
4. Explain types of lubricant and regimes of lubrication.
5. Explain various mechanisms of lubrication with its significance.
6. Identify the areas of applications for tribology.

Title of the Course: Project Management		L	T	P	Credit
Course Code: UMEE0517		3	-	-	3

Course Pre-Requisite: Fundamental knowledge of management

Course Description:

Course comprises of introduction to project management, project identification, selection and project planning. I covers concepts of project activities, work breakdown structure, activity duration, resource requirements. It also introduce about project scheduling, project risk management, project costing ,project execution, control and close out.

Course Objectives:

1. To define concepts of project and project management
2. To explain various steps in project identification, selection and planning
3. To identify details of work breakdown structure, activity duration, resource requirements
4. To decide about project schedules and durations using Gantt chart, network analysis
5. To analyse project risks and role of computers in project management
6. To analyse aspects of project costing, project execution, control and close-out

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Define concepts related to project and project management	I	Remembering
CO2	Explain steps in project identification, selection and project planning	II	Understanding
CO3	Identify aspects of work breakdown structure, activity duration, resource requirements	III	Applying
CO4	Make use of Gantt chart, network analysis in deciding project schedules and project durations	IV	Applying
CO5	Analyse project risks, role of computers , aspects of project costing, project execution, control and close-out	IV	Analyzing

CO-PO-PSO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1				2					2		3			1	1
CO2				2					2	1	3			1	1
CO3				2					2	1	3			1	1
CO4				2					2	1	3			1	1
CO5				2					2	1	3			1	1

Course Contents:

Unit 1: Introduction to Project Management Definition of a project, project management & its need, characteristics, objectives & importance of projects, classification of projects, project management process ,project management life cycle & its phases, roles and responsbilities of project managers, types of project managers, forms of project management-basic, programme, new venture& product management(pm)	07 Hrs.
Unit 2: Project Identification, Selection, Planning Project ideas and sources, steps in project identification process, feasibility studies and types, feasibility report and its contents, financial institutions, project break even point project planning-scope, delivery, resources, budget, quality & risk, forms of organization structures-functional. geographical, product, matrix, pure	07 Hrs.

Unit 3: Project Activities, Work Breakdown structure, Activity duration, Resource Requirements Work breakdown structure (wbs)-product oriented and functionally oriented wbs, responsibility chart and responsibility matrix, integrating wbs and organization structure methods for estimating activity duration, determining resource requirements	06Hrs.
Unit 4: Project Scheduling Activity, events, work packages, Gantt chart, scheduling of projects using network analysis PERT &CPM: Introduction to project evaluation and review, introduction to critical path method, deciding project duration using network diagram, finding critical path, calculation of earliest start time, latest finish time, slack, total float, free float, three time estimates, variance	08Hrs.
Unit 5: Project Risk Management Introduction, risk, risk management, steps in risk management, Risk Analysis, Use of computers in project management	04 Hrs.
Unit 6: Project Costing ,Project Execution, Control, Close-out Elements of cost estimates and budgets of projects, Introduction to methods for assessing economic viability of projects, Project execution & Control-conduct project execution and control kick-off, manage cssq (cost, scope, schedule, quality) monitor & control risk. manage project execution ,gain project acceptance, Project close-out, steps for closing the project	08 Hrs.

Textbooks:

1. Engineering Project Management-Parameshwar P Iyer-Vikas Publishing House Pvt Ltd
2. Project Management- S. Choudhury, - TMH Publishing Co. Ltd, New Delhi
3. Prasanna Chandra, ―Projects – Planning, Analysis, Financing, Implementation and Review, Tata McGraw Hill,4th Ed, 1997

References:

1. NYS Project Management Guidebook -Release 2
2. John M Nicholas, ―Project Management for business and technology, 2nd edition, Pearson Education Asia, 2001
3. Effective Project Management Robert K. Wysocki, Robert Beck. Jr., and David B. Crane; - John Wiley & Sons.
4. Total Project Management- The Indian Context- P. K. Joy, - Macmillan India Ltd., Delhi
5. Project Management in Manufacturing and High Technology Operations- Adedeji Bodunde Badiru, -John Wiley and Sons.
6. Fundamentals of PERT/ CPM and Project Management- S.K. Bhattacharjee; - Khanna Publishers, New Delhi

Unit wise Measurable students Learning Outcomes:

1. Student should be able to define concept related to project and project management
2. Student should be able to explain process involved in identifying project along with selection and project planning
3. Student should be able to explain concepts like work breakdown structure, activity duration, resource requirements
4. Student should be able to make use of Gantt chart and network analysis for optimum project schedules and durations.
5. Student should be able to analyse different kind of project risks, role of computers in project management
6. Student should be able to analyse aspects of project costing, project execution, control and close-out

Title of the Course: ENGINEERING ECONOMICS Course Code:UMEO0501	L	T	P	Credit
	3			3

Course Pre-Requisite: Basic knowledge of Process Engineering,

Course Description: Engineering management relies on the knowledge of engineering economics to be able to evaluate projects from a financial perspective. Optimizing financial performance of a project is a key responsibility of an engineer in the decision making process. This course is designed to present engineering students the major concepts and techniques of engineering economics that are needed in the decision making process. The emphasis of this course is on the analytical analysis of cost calculation/ estimation of component, fund management and economic aspects of a enterprise.

Course Objectives:

1. To acquire knowledge of Costing to be able to evaluate component/product from a financial perspective.
2. To apply analytical formulae to estimate the cost of a component.
3. To present engineering students the major concepts of fund management that are needed in the decision making process.
4. To emphasize the strong correlation between engineering design and manufacturing of products/systems and the economic issues they involve.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Identify elements of cost, demand and supply.	III	Applying
CO2	Estimate the cost of a component.	V	Evaluating
CO3	Evaluate projects from a financial perspective.	V	Evaluating
CO4	Solve engineering economic analysis problems.	III	Applying
CO5	Demonstrate the effects of depreciation, taxes, inflation and price change.	II	Understanding

CO-PO Mapping:

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

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30

ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:--- Introduction Introduction to Engineering Economy, Time value of money, Cash Flow, Lawof Supply and Demand, Types Of Efficiency , Definition and scope of Concept of cost, cost unit, cost center, classification of cost, Definition of costing, cost-price-profit equation, desirable conditions for a costing system. Cost Estimating: Definition, purpose and functions of Cost Estimation, role of Estimator, estimating procedures. , Break Even Analysis, Economic Order quantity.	6 **Hrs.**
Unit 2:--- Depreciation Elements of Cost, Depreciation Causes of depreciation of assets. Calculation of depreciation values using different methods of depreciation Review of purchasing procedure, recording of stock and consumption of Material by LIFO, FIFO, Weighted average method. (numerical on above)	7 **Hrs.**
Unit 3:--- Cost Estimation **3.1** Process of breaking down product drawing in to simpler elements or shapes, estimating the volume, weight and cost. Machine Hour Rate Calculation. Decision under risk and uncertainty.	7**Hrs.**
Unit 4:--- Overhead and Cost Accounting Method Methods of Overhead Allocation, apportionment, absorption of overheads.(Numerical) Cost Accounting Methods: Job costing, Batch costing, Unit costing, Process costing, Contract costing, Activity based costing. (numerical)	7 **Hrs.**
Unit 5:--- Fund Management and Taxation Sources of funds for business organization Concepts of wants, scarcity, choice, opportunity cost, demand and supply curves, price determination. Minimum Attractive Rate of Returns, Internal Rate of Returns (IRR) **Taxation:** Effect of taxation on economic studies, Introduction to Direct and Indirect tax, GST – concepts and general principles. **Introduction Circular Economy for sustainability**	7**Hrs.**
Unit 6:---Cost Control and Cost Reduction Budget meaning, Use of Budget in planning and control, Budgetary control, Budget objectives, classification of budgeting, standard cost, variance analysis, marginal cost, Zero Base Budgeting (ZBB)	6 **Hrs.**

Textbooks: 1. Mechanical Estimating and Costing By B.P. Sinha. Tata McGraw Hill Publishing Co. Ltd. N. Delhi 2. Mechanical Estimating and Costing T.R. Banga and S.C.Sharma, Khanna Publishers, Delhi-6	
References: 1] Principles & Practice of Cost Accounting – N. K. Prasad (Book Syndicate Pvt. Ltd.) 2. Costing Simplified: Wheldom Series – Brown & Owier (ELBS) 3. Cost Accounting: B. Jawaharlal (TMH) 4. Cost Accounting: R.R. Gupta. 5. Cost Accounting, 13/e - B. K. Bhar, (Academic Publishers, Kolkata) 6. Cost Accounting: Jain, Narang (Kalyani Publishers) 7. A Text Book of Estimating and Costing Mechanical – J.S. Charaya & G. S. Narang (Satya Prakashan) 8. Mechanical Estimation and Costing – TTTI, Chennai (TMH) 9. Theory & Problems of Management & Cost Accounting – M.Y. Khan, P. K. Jain (TMH)	
Unit wise Measurable students Learning Outcomes: **1 Student will be able to distinguish elements of cost.** **2 Calculate depreciation and value of stock.** **3 Estimate weight of a given component and cost of machining.** **4 Calculate overhead cost, cost with cost accounting methods.** **5 Identify cost reduction techniques and estimation of budget.** **6. Identify various sources of fund for financial requirement of organization.**	

Title of the Course: Supply Chain Management	L	T	P	Credit
Course Code: UMEO0502	3	---	---	---

Course Pre-Requisite: None

Course Description: This course provides an introduction to supply chain management, covering key concepts such as supply chain drivers and metrics, sourcing strategies, distribution network design, inventory strategies, and achieving strategic fit and scope. The course also addresses the role of information technology in SCM. By the end of the course, students will have a comprehensive understanding of the key concepts, strategies, and practices in supply chain management.

Course Objectives:

1. To analyze supply chain drivers and metrics and develop strategies for improving supply chain efficiency and effectiveness.
2. To evaluate sourcing strategies and make informed decisions about supplier selection, outsourcing, and total cost of ownership.
3. To design and manage effective distribution networks and inventory strategies to optimize supply chain performance.

Course Learning Outcomes:

CO	After the completion of the course, the student should be able to	Bloom's Cognitive level	Descriptor
CO1	**Recall** the key concepts and components of supply chain management, such as supply chain drivers and metrics, sourcing strategies, distribution network design, and inventory strategies.	I	Remembering
CO2	**Explain** how various supply chain drivers, such as facilities, inventory, transportation, sourcing, pricing, and information, impact supply chain performance and can be optimized to improve efficiency and effectiveness in supply chain management.	II	Understanding
CO3	**Apply** basic analytical skills to solve supply chain management problems, such as evaluating supply chain performance metrics, optimizing inventory levels, and designing distribution networks.	III	Applying

CO-PO Mapping:

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

Assessments:

Teacher Assessment:

The assessment will be based on end semester theory exam (ESE) on entire syllabus.

Assessment	Marks
ESE	100

Course Contents:

Unit 1: **Introduction to Supply Chain Management (SCM):** What Is a Supply Chain?, Historical Perspective, The Objective of a Supply Chain, The Importance of Supply Chain Decisions, Decision Phases in a Supply Chain, Process Views of a Supply Chain, Examples of Supply Chain, Role of IT in Supply Chain Management.	**5 Hrs**
Unit 2: **Supply Chain Drivers And Metrics:** Impellers of Supply Chain, Financial Measures of Performance, Drivers of Supply Chain Performance, Framework for Structuring Drivers, Facilities, Inventory, Transportation, Information, Sourcing, Pricing, Infrastructure, International Logistics	**7 Hrs.**
Unit 3: **Supply Chain Sourcing Strategies:** Demand Forecasting In A Supply Chain, The Role of Forecasting in a Supply Chain, Characteristics of Forecasts, Time-Series Forecasting Methods, The Role of IT in Forecasting Sourcing Decisions In A Supply Chain: The Role of Sourcing in a Supply Chain, In-House or Outsource?, Total Cost of Ownership, Supplier Selection—Auctions and Negotiations, The Impact of Incentives When Outsourcing, Making Sourcing Decisions in Practice	**7 Hrs.**
Unit 4: **Supply Chain Distribution Strategies:** key factors to be considered when designing a distribution network, strengths and weaknesses of various distribution options, Online Sales and Distribution Network **Network Design in the Supply Chain**: role of network	**7 Hrs**

design in a supply chain, factors influencing supply chain network design decisions, Use of optimization for facility location and capacity allocation decisions	
Unit 5: **Supply Chain Inventory Strategies:** Importance of aggregate planning as a supply chain activity, Aggregate Planning Strategies, Formulate and solve basic aggregate planning problems. **Economies of Scales in Supply Chain:** Balance the appropriate costs to choose the optimal lot size and cycle inventory in a supply chain, the impact of quantity discounts on lot size and cycle inventory.	**7 Hrs**
Unit 6: **Supply Chain Performance:** Achieving Strategic Fit And Scope: Competitive and Supply Chain Strategies, Achieving Strategic Fit, Expanding Strategic Scope, Challenges to Achieving and Maintaining Strategic Fit, Achieving and Maintaining Strategic Fit in Emerging, Retail Markets: The Indian Scenario	**5 Hrs.**

Textbooks:

1. Chopra, S., & Meindl, P. (2016). Supply Chain Management: Strategy, Planning, and Operation (6th ed.). Pearson.
2. Hugos, M. H. (2018). Essentials of supply chain management (4th ed.). John Wiley & Sons.

References:

1. Simchi-Levi, D., Kaminsky, P., & Simchi-Levi, E. (2019). Designing and managing the supply chain: Concepts, strategies, and case studies (4th ed.). McGraw-Hill Education.
2. Coyle, J. J., Langley, C. J., Novack, R. A., & Gibson, B. (2017). Supply chain management: A logistics perspective (10th ed.). Cengage Learning.

Unit wise Measurable students Learning Outcomes:

1. Unit 1: Upon completion of this unit, students will be able to identify the decision phases in a supply chain and explain the role of information technology in supply chain management.
2. Unit 2: Upon completion of this unit, students will be able to evaluate the financial measures of supply chain performance and identify the drivers of supply chain performance.
3. Unit 3: Upon completion of this unit, students will be able to apply time-series

forecasting methods and evaluate sourcing decisions in a supply chain based on the total cost of ownership.

4. Unit 4: Upon completion of this unit, students will be able to analyze the strengths and weaknesses of various distribution options and apply optimization techniques for facility location and capacity allocation decisions.
5. Unit 5: Upon completion of this unit, students will be able to apply aggregate planning strategies and evaluate the impact of quantity discounts on lot size and cycle inventory in a supply chain.
6. Unit 6: Upon completion of this unit, students will be able to develop competitive and supply chain strategies and evaluate challenges to achieving and maintaining strategic fit in emerging retail markets, such as the Indian market.

Title of the Course: Enterprise Resource Planning Course Code: UMEO0503	L	T	P	Credit
	3	0	0	3

Course Pre-Requisite:

This course requires the basic knowledge of thefollowing:

1. Basics of Industrial Management
2. Basics of Computer Software and Hardware.

Course Description:

In today's world managing the future means managing information. Almost all organizations are turning to some sort of ERP package as a solution to their information management problems.ERP packages if chosen correctly, implemented judiciously and used efficiently have the ability to raise productivity and profits of companies. Knowledge of ERP systems is therefore crucial for today's day to day working.

Course Objectives:

1. To elaborate basics, evolution and importance of ERP.
2. To explain ERP and related technologies.
3. To explain the students the business modules of ERP.
4. To explain the ERP Implementation process.
5. To apply Programming knowledge in ERP Software design.
6. To explain the ERP market with the help of case studies.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Bloom's Cognitive Descriptor
CO1	**Explain the** Evolution of an ERP system and ERP market.	II	Understand
CO2	**Explain** ERP and related information technologies.	II	Understand
CO3	**Summarize**the business modules of ERP andthe implementation process of ERP package	II	Understand
CO4	**Apply** the programming knowledge in ERP software design	III	Apply

CO-PO-PSO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO1 1	PO12	PSO1	PSO2	PSO3
CO1	2														
CO2	2														
CO3	2	2											2	2	
CO4	2														

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:--- Introduction to ERP Introduction, Business Functions and Business Processes, Role of the Enterprise, Evolution, Reasons for the growth of ERP market, Advantages, Limitations of ERP.	5**Hrs.**
Unit 2:--- ERP and Related Technologies Business Process Reengineering (BPR), Business Intelligence (BI),Business Analytics (BA), Data warehousing, Data mining, OLAP,Product Life Cycle Management (PLM), Supply Chain Management (SCM), Customer relationship Management (CRM), Geographic Information System (GIS), Technological Advancement – ERP Bolt-ons, Middleware, ERP Security Issues.	8**Hrs.**
Unit 3:--- ERP Modules Introduction and study of Business modules like Finance, Mfg. and Production, HR, Plant Maintenance, Quality and Material Management, Sales and Distribution.	6**Hrs.**
Unit 4:--- ERP Implementation Life cycle and Implementation process Challenges to successful ERP Implementation, Objectives of ERP Implementation, Different Phases of ERP Implementation , ERP Deployment models, ERP Transition strategies, Organization of the ERP Project Team, Success and Failure factors of the ERP Implementation.	8**Hrs.**
Unit 5: ---Development and Applications of ERP Module Design and Development of sample ERP module, Gathering requirements, Deciding Technology, Development phase, Testing of ERP, User Feedback.	7**Hrs.**
Unit 6:--- ERP Market and Case Studies Brief account of ERP market, various ERP packages like SAP, BAAN, Oracle, QAD, PeopleSoft etc, Case studies based on implementation of ERP forvarious areas in Manufacturing, Marketing and other businesses, E- Commerce, ERP career.	6**Hrs.**
Textbooks: 1. "Enterprise Resource Planning", Alexis Leon, Tata McGraw Hill Publication, ISBN 0-7-463712-6. 2. "Enterprise Resource Planning", Bret Wagner, Delmar Learning, International Edition, ISBN 10: 1439081085, ISBN–13: 978-1439081082. 3. "Enterprises Resource Planning", Venkateshswara, Scitech Publication. 4. "Entrepreneurship",Chris Boulton, Patric Turner, Willey India. 5. "Management Information System",S. Sadagopan, PHI, New Delhi, 2nd Edition.	
References: 1. "Modern ERP: Select Implement and Use", Marianne Bradford, Hand M Books, lulu.com, ISBN: 978-0-557-01291-6. 2. "Enterprises Resource Planning", E.F. Monk, B.J. Wagner, Cengage Learning. 3. "Enterprises Resource Planning", A. R Singla, Cengage Learning. 4. "Enterprises Resource Planning-Concepts and Practices", Vinod Kumar Garg and Venkitakrishnan N. K. , PHI, New Delhi.	

Title of the Course: Innovation Tools and Methods for Entrepreneurs
Course Code: UMEO0504

L	T	P	Credit
2	-	-	

Course Pre-Requisite:
A Student who is going to enroll for this course should have following abilities:
1. Creativity and Innovativeness
2. Problem identification
3. Apply design thinking approach to develop working prototype
4. Structured approach to problem solving

Course Description:
This course helps students to identify different tools for developing the solution that he has already learned to ideate in the previous course "Creativity and Design Thinking". Further, students get information about various tools to carry out competitor analysis and user journey map. It would help him to come up with detailed specifications and USP of the product based on the competitor survey.

Course Objectives:
1.To explain structured approach to define the problem with every possible detail, identify conflicts and solve them.
2.To apply user journey map to the selected problem to show user interaction at various stages
3.To analyze the solutions provided by competitors for effectiveness and gaps if any.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		Level	Descriptor
CO 1	**Recall** innovation and various innovative tools	I	Remembering
CO 2	**Choose** innovation tool for product development	I	Remembering
CO 3	To **demonstrate** user journey map to the selected problem to show user interaction at various stages	II	Understanding
CO 4	To **analyze** the solutions provided by competitors for effectiveness and gaps if any.	III	Applying
CO 5	**Make use of** Design thinking process for problem statement to prototype development.	III	Applying
CO 6	**Develop** Business Model for idea developed over the period	III	Applying

CO-PO-PSO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1															
CO 2					2										
CO 3															
CO 4									1				2		
CO 5											2				
CO 6												2		2	

Assessments:
Teacher Assessment: Two Components of In Semester Evaluation (ISE)

~~Assessment~~	~~Mark~~
~~ISE-1~~	~~50%~~
~~ISE-2~~	~~50%~~

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.

Course Contents:	Hrs.
Unit-1Systematic Innovation Principals of Innovations, Ethics of Innovation, Innovation policy, Innovation systems, Sustainability, Systemic Innovation Systems Thinking,	**4 Hr**
Unit-2 TRIZ Introduction,Central concepts behind TRIZ, features of TRIZ,Use of TRIZ Principles, Advantage of TRIZ	**4Hr**
Unit-3User Journey Map (UJM) Introduction, Need of Customer Journey Mapping, Step-by step process of UJM creation,Content of User Journey Map, The benefits of Customer Journey Mapping,	**4 Hr**
Unit-4Competitor Analysis: Introduction, Competitive Analysis Framework, Benefits of using Competitive Analysis Framework,Types of Competitive Analysis Framework	**4Hr**
Unit-5 Design Thinking: Introduction, Working of Design Thinking, Phases of Design Thinking,Ways to Get Started with Design Thinking, Advantages & Limitations of Design Thinking	**4 Hr**
Unit-6 Business Model Canvas: Introduction to Business Models, Defining the Business Model, Purpose, Role and Importance of Business Models, Key elements of a Business Model and the interactions & interdependencies among the elements.	**4Hr**
Textbooks: 1.The innovation algorithm: TRIZ, systematic innovation and technical creativity, GS Al′tshuller - 1999 2.TRIZ: Systematic innovation in manufacturingYT San, YT Jin, SC Li - 2009 3.User experience mappingPW Szabo - 2017 4.Online computation and competitive analysisA Borodin, R El-Yaniv– 2005 5.Operating model canvasA Campbell, M Gutierrez, M Lancelott - 2017	
References: 1. J. Knapp. Design Sprint, Simon & Schuster Publisher. 2. D. Silverstein. The Innovator's Toolkit, Wiley Publishing House. 3. M. A. Orloff. ABC-TRIZ: Introduction to creative design thinking with modern TRIZ modeling, Springer Publication. 4. M. Laverty. Entrepreneurship, OpenStax Publication.	
Unit wise Measurable Students Learning Outcomes: 1.Produces a surplus of innovative and wide ranging solutions addressing the identified needs. 2.Repeating patterns of problem and solution, understanding the contradictions present in a situation, and developing new methods of using scientific effects. 3.Identify opportunities for growth by understanding customer expectations and perceptions at various touchpoints. 4.It will help to recognize how entrepreneur can enhance your own business strategy. 5.Understand and be able to explain the purpose, role and importance of business models, including the key elements of a business model and the interactions and interdependencies among the elements. 6.Improve problem-solving skills and collaboration among students	

Title of the Course: Operations Research	L	T	P	Credit
Course Code:UMEO0505	3	-	-	3

Course Pre-Requisite: This course requires the basic knowledge of the following:

1. Basics of Mathematics.
2. Basic functional areas in Engineering

Course Description:-

Operation Research is now has wide scope of application in various fields. OR Techniques help in solving various industrial problems. These include methods like Linear Programming, Transportation, Assignment, Sequencing, Queing, Gaming, Inventory Control, Replacement, Decision theory and network modeling. These techniques help to obtain the optimal solutions.

Course Objectives:

1. To state the scope and importance of Operation Research.
2. To understand various OR Techniques for solving industrial and real life problems.
3. Apply the various models of operation research to solve industrial and real life problems to get optimal solutions.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Develop the LP model to solve engineering and management problems	**3**	Applying
CO2	Analyze assignment models for engineering problems to get optimal solution.	**4**	Analyzing
CO3	Discuss different transportation models.	**5**	Creating
CO4	Solve game problems for pay-off matrix to get optimal mix strategy	3	Applying
CO5	Make use of queing, sequencing and replacement theories to get optimal solutions for various problems.	3	Applying
CO6	Construct networks for optimizing project duration and cost.	3	Applying

CO-PO Mapping:

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

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1: Introduction to Operation Research and Linear Programming Problems History and development of OR, Scope and Applications, Types of Operations Research, OR models and their applications in different areas **Linear Programming Problems** Formulation of LPP, Various methods of solving LPP- Graphical Method, Simplex Method (Minimization and maximization), Concept of Duality.	**10 Hrs.**
Unit 2: Transportation Model and Assignment Model **A. Transportation Model**: Basic Transportation problems, Conditions for testing optimality, unbalanced transportation problems, degeneracy. **B. Assignment Model**: Allocation Methods to solve balanced and unbalanced assignment problems, HAM, Alternate optimal solution, Traveling salesman problem	**08 Hrs.**
Unit 3: Gaming Theory Introduction, two–person zero-sum game, Minimax and Maximin principle. Saddle point. Methods for solving game problems with mixed strategies. Introduction to graphical, and iterative methods for solving game problems	**04 Hrs.**
Unit 4: Queing Theory and Sequencing **A. Queuing Theory:** Queuing Systems: Introduction, cost associated with, Classification of queuing models. Kendall's notations. Models: {(M/M/1): (α / FSFS)}. Single server models. **B. Sequencing** Sequencing of n jobs on two machines, n jobs on three machines.	**06 Hrs.**
Unit 5: Replacement Theory Introduction, Replacement model for items whose maintenance cost increases with time (money value constant) and with change in money value, selection of best machine, replacement of items that fail suddenly, individual and group replacement policies.	**04 Hrs.**
Unit 6:--- Network Model : Introduction, Concepts and construction of network diagrams, CPM, PERT, Probability of completing projects by given date, Crashing Analysis, Resource Scheduling.	**08 Hrs.**

Textbooks:

1. Operations Research, S. D. Sharma,
2. Operations Research, Hira Gupta, S. Chand & Co. Ltd., New Delhi.
3. Operations Research, Kanti Swarup, Man Mohan and P. K.Gupta, Sultan Chand & Sons, New Delhi.

4. “Optimization in Engineering”, Biswal, SciTech Publication,2nd Edition.
5. “Operations Research”, Manohar Mahajan Dhanapat Rai and Sons.
6. “Engineering Optimization Methods and Application”, A Ravindran ,K.M. Ragdell ,G.V. Rklaitis, Willey India Ltd

References:

1. Operations Research-An Introduction, H. Taha, Maxwell Macmillan, New York.
2. Principles Operations Research, Wrangler, Prantice-Hall of India, New Delhi.
3. “Production and Operation Management”, Tripathy, SciTech Publication, 2nd Edition.
4. “Introduction to Operation Research”, Paneer Selvam, Prentice Hall of India publication, 2nd Edition.
5. Wiest J. D.• & Levy F. K.: Managerial Guide to PERT/CPM, Prentice Hall of India Pvt. Ltd.
6. Srinath L.S “PERT• & CPM principles & Applications” Affiliate East West Press (P) Ltd., New Delhi, 1975.

Title of the Course: Intellectual Property Rights	**L**	**T**	**P**	**C**
Course Code: UMEA0501	**2**	**-**	**-**	**0**

Course Pre-Requisite: Innovative and Creative Mindset, Genuine interest towards Entrepreneurship Development and Management.

Course Description:

This course will cover the philosophy of intellectual property rights, various technical and legal dimensions of IPR, and implications of IPR for growth and development of science and technology, along with the various socio-economic and ethico-legal consequences of IPR on economic development. This course also covers all kinds of Intellectual Property Rights and focuses on India's new IP Policy and Government schemes for IPR.

Course Objectives:

1. To introduce fundamental aspects of Intellectual property Rights to students who are going to play a major role in development and management of innovative projects in industries. .
2. To disseminate knowledge on patents, patent regime in India and abroad and registration
3. To disseminate knowledge on copyrights and its related rights and registration aspects To disseminate knowledge on trademarks and registration aspects
4. To disseminate knowledge on Design, Geographical Indication (GI), Plant Variety and Layout Design Protection and their registration aspects
5. To create awareness about current trends in IPR and Govt. steps in fostering IPR

Course Learning Outcomes:

CO	After the completion of the course	Bloom's Cognitive	
		Level	Descriptor
CO1	Describe about the concepts of Intellectual Property Rights	II	REMEMBERING
CO2	Distinguish and understand the world of Intellectual Property	III	UNDERSTANDING
CO3	Explain why it needs to be protected? How is it protected?	III	APPLYING
CO4	Analyse discuss and debate about the latest legal problems confronting the world and the solutions being offered	III	ANALYSE
CO5	Consider new and upcoming areas of Intellectual Property (IP) like Biotechnology, Domain Names, Creative Commons etc.	II	UNDERSTANDING

CO-PO Mapping:

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

Strength of Correlation: Key: 3: High, 2:Medium, 1:Low

Assessments :
Teacher Assessment:

Assessment	Marks
ESE	100

ESE: Assessment is based on 100% course content with equal weightage for course conten covered.

Course Contents:

Unit 1: - INTRODUCTION TO INTELLECTUAL PROPERTY RIGHTS: **4 Hrs.**

Concept and meaning of IPR, Need for IPR, Kinds of Intellectual Property rights Patent, Copyright, Trade Mark, Design, Geographical Indication, Plant Varieties and Layout Design. IPR in India : Genesis and development Introduction to TRIPS, WIPO AND WTO.

Unit 2: - PATENTS 5 **Hrs.**

Meaning of Patent, Patents - Elements of Patentability: Novelty , Non Obviousness (Inventive Steps), Industrial Application - Non - Patentable Subject Matter - Registration Procedure, Rights and Duties of Patentee, Assignment and licence , Restoration of lapsed Patents, Surrender and Revocation of Patents, Infringement, Remedies & Penalties - Patent office and Appellate Board

Unit 3: - COPYRIGHTS **4 Hrs.**

Definition, Types of copy right, Registration Procedure, Term of protection, Ownership of copyright, Assignment and licence of copyright - Infringement, Remedies & Penalties – Related Rights - Distinction between related rights and copyrights

.

Unit 4: TRADEMARKS : **04 Hrs.**

Concept of Trademarks - Different kinds of marks (brand names, logos, signatures, symbols, well known marks, certification marks and service marks) - Non Registrable Trademarks - Registration of Trademarks - Rights of holder and assignment and licensing of marks - Infringement, Remedies & Penalties - Trademarks registry and appellate board

Unit 5: - OTHER FORMS OF IP **07 Hrs.**

- **Design**

  Design: meaning and concept of novel and original - Procedure for registration**,**
- **Geographical Indication (GI)**

  Geographical indication: meaning, and difference between GI and trademarks - Procedure for registration**,**
- **Plant Variety Protection**

  Plant variety protection: meaning and benefit sharing and farmers' rights – Procedure for registration
- **Layout Design Protection** **02 Hrs.**

  Layout Design protection: meaning – Procedure for registration

Unit 6: CURRENT CONTOUR

India`s New National IP Policy, Govt. of India step towards promoting IPR – Govt. Schemes in IPR

References:

1. Nithyananda, K V. (2019). Intellectual Property Rights: Protection andManagement. India, IN: Cengage Learning India Private Limited.

   2. Neeraj, P., & Khusdeep, D. (2014). Intellectual Property Rights. India, IN: PHIlearning Private Limited.
2. Ahuja, V K. (2017). Law relating to Intellectual Property Rights. India, IN: LexisNexis
3. N.R. Subbaram.S. Viswanathan, "Hand book Indian Patent Law and, Practice"Printers and publishers Pvt, Ltd, 2008.
4. Dr. S.R.Myneni, "Law of Intellectual Property", 9th Ed, Asia law House,2019
5. Indian Patent Law : Legal and Business Implications" by AjitParulekar, Sarita D'Souza Macmillan India publication, 2006
6. "Agriculture and Intellectual Property Rights", edited by: Santaniello,V., Evenson, R.E., Zilberman, D. and Carlson, G.A. University Press publication, 2003
7. David Bainbridge: Intellectual Property (2002), Pearson Education Ltd, New Delhi
8. . Pearson & Miller : Commercial Exploitation of Intellectual Property (2004), University Law Publishing Co. Pvt. Ltd, Delhi.
9. Prabhuddha Ganguli:Intellectual PropertyRights–Unleashing Knowledge Economy, 2001, Tata-Mcgraw Hill, New Delhi.
10. Ganguli Prabuddha Gearing up for Patents…..The Indian Scenario", Universities Press (1998)
11. Inventing the Future: An introduction to Patents for small and medium sized Enterprises; WIPO publication No. 917.
12. Looking Good : An Introduction to Industrial Designs for Small and Mediumsized Enterprises; WIPO publication No.498. URL
13. Creative Expression: An Introduction to Copyright and Related Rights for Small and Medium-sized Enterprises; WIPO publication No. 918
14. Making a Mark: An Introduction to Trademarks for Small and Medium-sized Enterprises; WIPO publication No. 900

Title of the Course: HEAT TRANSFER LAB Course Code:UMEC0505	L	T	P	Credit
	-	-	2	1

Course Pre-Requisite: Differential calculus, Integral calculus, Fluid mechanics

Course Description: The course deals with various experiments related to conduction, convection and radiation mode of heat transfer so as to understand the fundamentals and application of governing equations used in heat transfer.

Course Objectives:

CLO1: To provide the students the fundamentals of conduction, convection and radiation.

CLO2:To train students with good scientific and engineering breadth in the areas of heat transfer, so as to comprehend, analyze, design and create novel products and solutions for the real life problems

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Bloom's Cognitive Descriptor
CO1	Explain fundamentals of Heat and Mass Transfer mechanisms.	2	Understanding
CO2	Develop differential equations for Heat Transfer mechanisms .	3	Applying
CO3	Analyze the performance of heat exchangers.	4	Analyzing
CO4	Estimate the rate of heat transfer at specified temperature difference.	5	Evaluating

CO-PO, PSO Mapping:

CO	PO1	PO2	PO3	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	-	-	-	-	-	-	-	2	-	1
CO2	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	3	-	-	-	-	-	-	2	-	-	-	3	2	-
CO4	-	3	-	-	-	-	-	-	-	-	-	1	3	2	-

Assessments :

Teacher Assessment:

One component of In Semester Evaluation (ISE) and one End Semester Examination (ESE) having 50%, and 50% weights respectively.

Assessment	Marks
ISE	25
ESE	25

ISE are based on practical performed/ Quiz/ Mini-Project assigned/ Presentation/ Group Discussion/ Internal oral etc.
ESE: Assessment is based on oral examination
Note: Experiment No. 1 to 10 shall be selected for the POE examination and All should be included in Journal.

Course Contents:

Experiment No. 1:Thermal conductivity of insulating powder	**02 Hrs.**
Experiment No. 2: Heat transfer through lagged pipe	**02 Hrs.**
Experiment No. 3: Heat transfer through composite wall	**02 Hrs.**
Experiment No. 4: Heat transfer by natural convection	**02 Hrs.**
Experiment No. 5: Emissivity measurement apparatus	**02 Hrs.**
Experiment No. 6: Stefan -Boltzmann apparatus	**02 Hrs.**
Experiment No. 7: Parallel and counter flow heat exchanger	**02 Hrs.**
Experiment No. 8: Heat transfer by forced convection	**02 Hrs.**
Experiment No. 9: Heat transfer through pin fin	**02 Hrs.**
Experiment No. 10: Heat pipe demonstration	**02 Hrs.**
Experiment No. 11: Study and Demonstration of Drop wise and Film wise Condensation	**02 Hrs.**
Experiment No. 12: Study and Demonstration of Heat Pipe	**02 Hrs.**
Experiment No. 13: Study and Demonstration of Pool Boiling and Forced Boiling	**02 Hrs.**

Textbooks:
1. Heat Transfer: A Practical Approach, Yunus A. Cengel , McGraw-Hill Higher Education; 2 edition
2. Fundamentals of Heat & Mass Transfer ,7th Edition, Frank P. Incropera, Wiley.
3. A Course in Heat and Mass Transfer,: S. C. Arora (Author), S. Domkundwar (Author), Anand V. Domkundwar
4 Heat and Mass transfer: J Holman (Author), Souvik Bhattacharyya , McGraw Hill Education; 10 edition

References:
1 Fundamentals of Engineering Heat and mass trasnfer, R C Sachdeva
2. Heat And Mass Transfer, Data Book, C.P. Kothandaraman, New Age International Private Limited; Ninth edition.

Experiment wise Measurable students Learning Outcomes: At the end of each experiment the students will be able to

1. Determine the thermal conductivity of insulating powder.
2. Determine the thermal conductivity of insulating material in lagged pipe
3. Determine the equivalent thermal conductivity and thermal resistance of insulating powder.

4. Determine the heat transfer coefficient in natural convection of vertical cylinder.
5. Determine the emissivity of given grey plate.
6. Determine the stefan-boltzmann constant experimentally.
7. Determine the lmtd, effectiveness of parallel and counter flow heat exchanger.
8. Determine the heat transfer coefficient in forced convection.
9. Determine the effectiveness and efficiency of pin fin.
10. Demonstrate the working principle of heat pipe
11. Demonstrate Drop wise and Film wise Condensation
12. Demonstrate of working of Heat Pipe
13. Explain Pool Boiling and Forced Boiling Phenomenon

Title of the Course: Geometric Dimension and Tolerancing Lab **Course Code:** UMEC0506	**L**	**T**	**P**	**Credit**
	-	**-**	**2**	**1**

Course Pre-Requisite: Basic of Physics, Mathematics, Statistics Basic Knowledge of different units, types of errors in measurement and basic electrical components with their principle. Basic knowledge of scale, scale factor and differentmeasurement with units. Also knowledge of Basics of Geometrical Dimensional Tolerances, limit, fits

Course Description:

The course integrates measurements of industrial parts with various mechanical and Electro- Mechanical measuring instruments and their usage.

Course Objectives:

The objective of this course is to make the student aware of:

1. To develop students knowledge of basics of Measurements, Metrology and measuring devices.
2. To know the concepts of various measurement systems & standards with regards to realistic applications.
3. The application of principle of metrology and measurements in industries.

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive level	Descriptor
CO1	List various geometrical tolerances used in production drawing	1	Remembering
CO2	Explain the significance of measurement system, errors, calibration of measuring devices	2	Understanding
CO3	Demonstrate use of metrological tools for linear, angular measurements	2	Understanding
CO4	Explain the basics of standards of measurement, limits, fits & tolerances industrial applications	2	Understanding
CO5	Analyze Manufacturing process with the help of Control Charts and Process Capability	4	Analyzing

CO-PO Mapping:

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	**2**			**1**	**2**								**1**	**2**	**2**
CO2	**2**	**2**	**2**	**2**	**2**		**1**						**3**		
CO3	**2**	**1**		**2**	**2**		**1**						**3**	**2**	
CO4	**2**	**2**	**2**	**2**			**1**						**3**		
CO5	**2**	**2**		**2**	**2**		**1**						**3**	**2**	

Assessments :
Teacher Assessment:

Assessment	Marks
ISE	25

One component of In Semester Evaluation (ISE) 100% weight

ISE are based on practical performed/ Quiz/ Mini-Project assigned/ Presentation/ Group Discussion/ Internal oral etc.

Course Contents:

Experiment No. 1:--- Study & Use of various linear measuring instruments (Vernier and micrometers) **Aim and Objectives:** **Outcomes:** Demonstrate use of linear Measuring Instruments **Theoretical Background:** **Experimentation:** Use of instrument, Measurement and Calculation withInterpretation **Results and Discussions:** **Conclusion:**	2Hrs.
Experiment No. 2:--- Study and use of mechanical & pneumatic comparator **Outcomes:** Demonstrate use of comparators **Theoretical Background:** Construction & Working of comparators **Experimentation:** Use of instrument, calibration , Measurement and Calculation with Interpretation **Results and Discussions:** **Conclusion:**	2 Hrs.
Experiment No. 3:--- Study & use of Bevel protractor and Sine Bar for measurement of Angle. **Outcomes:** Demonstrate use of Angle Measuring Instruments **Theoretical Background:** Construction & Working of angle measuring instruments **Experimentation:** Use of instrument, calibration , Measurement and Calculation with Interpretation **Results and Discussions:Conclusion:**	2Hrs.
Experiment No. 4:--- An assignment on geometric dimension and tolerance (concept, symbols, inspection) **Aim and Objectives:** **Outcomes:** Demonstrate geometric dimension and tolerance **Theoretical Background:** Concept ,symbol, application **Experimentation:** **Results and Discussions**	2 Hrs.
Experiment No. 5:--- Measurements of Screw thread parameters using two wire method **Outcomes:** **Theoretical Background:** **Experimentation:** Use of instrument, Measurement and Calculation withInterpretation **Results and Discussions:Conclusion:**	2 Hrs

Experiment No. 6:--- Measurement of gear tooth thickness using gear tooth vernier caliper. **Outcomes:** Demonstrate use of Gear Measuring Instruments **Theoretical Background:** **Experimentation:** Use of instrument, Measurement and Calculation with Interpretation **Results and** **Discussions:** **Conclusion:**	2 Hrs.
Experiment No. 7:--- Study & Use of Co0rdinate measuring machine (CMM) for dimension measurement (Linear & Geometric) **Outcomes:** Demonstrate use of CMM **Theoretical Background:** **Experimentation:** Use of CMM, Measurement and Calculation with Interpretation **Results and Discussions:** **Conclusion:**	2 Hrs.
Experiment No. 8 :--- Study & use of Variable (X-Bar –R chart) chart **Outcomes:** Demonstrate use of X-bar and Rchart **Theoretical Background:** Statistical concepts, Control charts **Experimentation:** Data collection, use of statistical techniques, data analysis, calculation, plotting of graph with interpretation **Results and Discussions:** **Conclusion:**	2 Hrs.
Experiment No. 9:--- Study & use of Attribute (P) chart **Outcomes:** Demonstrate use P-chart **Theoretical Background:** Statistical concepts, Control charts **Experimentation:** Data collection, use of statistical techniques, data analysis, calculation, plotting of graph with interpretation **Results and** **Discussions:** **Conclusion:**	2 Hrs.
Experiment No. 10:--- Study and use of dial indicator as a mechanical comparator for run out (eccentricity), roundness Measurement **Outcomes:** Demonstrate use dial & bench center for roundness & runout inspection **Theoretical Background:** **Experimentation:** Setting of instrument**,** method of measurement, calculation, plotting of graph with interpretation **Results and Discussions:** **Conclusion:**	2 Hrs
Textbooks: Textbooks: 1. R.K. Jain, "Engineering Metrology", Khanna Publisher, 2. I.C. Gupta, "Engineering Metrology", Dhanpat Rai Publications., 3. M. Mahajan, "Statistical Quality Control" Dhanpat Rai & Co., 2012 4. R.C. Gupta, "Statistical Quality Control", Khanna Publication, 1st Edition,1978	

References:

1. "Engineering Metrology", I.C. GUPTA, DhanpatRai and Sons, 1988, 2nd Edition.

2. "Practical Engineering Metrology", Sharp K.W.B. Pitman, London, 1973, 1st Edition.

3. Beckwith T.G, and N. Lewis Buck, Mechanical Measurements, Addison Wesley, 1991,5th edition,

4. N.V Raghavendra and L. Krishnamurthy, Engineering Metrology and Measurements, Oxford University Press, 2014.

5. Serope Kalpakjian and Steven R. Schmid, Manufacturing, Engineering & Technology, Pearson, Sixth Edition

Experiment wise Measurable students Learning Outcomes:

1. Students are able to select proper instrument for particular application
2. Students will demonstrate use of pneumatic and mechanical comparator
3. Students will demonstrate use of Bevel protractor and Sine bar.
4. Students will demonstrate use of floating carriage micrometer & two wire method formeasurement of thread diameter
5. Students will demonstrate use of Bevel protractor and Sine bar.
6. Students will demonstrate the geometric dimensioning and tolerancing
7. Students will demonstrate use of CMM
8. Students will construct and interpret the control charts for variable data.
9. Students will construct and interpret the control charts for attribute data

Title of the Course: Dynamics of Machines Lab Course Code: UMEC0507	L	T	P	Credit
	-	-	2	1

Course Pre-Requisite: Applied Mechanics, Engineering Physics, Kinematics of Machines.

Course Description:

This Lab course is an introduction to the Dynamics and Vibrations of Lumped-Parameter models of Mechanical Systems. Experiments included are related to Inertia forces and torques in mechanisms, Balancing of multi-cylinder in-line engines, Gyroscopic motion: Simple theory of gyroscopic couple, gyroscopic effects in machinery. Experiments on Free and forced vibrations of one-degree-of-freedom systems with and without viscous damping.

Course Objectives:

1. Identify the various types of gear trains used for transmission of motion and power.
2. Analyze the gyroscopic effects on vehicles, aero plane and ship.
3. Analyze the problems on balancing of rotary and reciprocating masses
4. Perform force analysis of simple mechanisms and balancing
5. Study basic concepts of vibration analysis

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Define various terminology related to kinematics of machine elements.	3	Applying
CO2	Indentify the various mechanism and its components.	3	Applying
CO3	Apply analytical formulae to simple mechanisms to calculate design parameters.	3	Applying
CO4	Analyze dynamics of simple mechanisms.	4	Analyze

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3														
CO2	2	2	1												
CO3	2	2	2	1	1								1	1	1
CO4		3	2	1	1	1	1	1	1	1			2	2	2

Assessments :

Teacher Assessment:

One component of In Semester Evaluation (ISE) and one End Semester Examination (ESE) having 50%, and 50% weights respectively.

Assessment	Marks
ISE	25
ESE(POE)	25

ISE are based on practical performed/ Quiz/ Mini-Project assigned/ Presentation/ Group Discussion/ Internal oral etc.ESE: Assessment is based on Practical oral examination

Laboratory Contents:

Experiment No.1:- Demonstration on Differential Gear Train & Torque Measurement in Epicyclic Gear Train. Aim & Objectives: To study various types of gear trains and analysis of Epicyclic Gear Train. Outcomes: Able to analyze the Epicyclic Gear Train. Experimentation: Use of Tabular method for the Analysis of gear train model	02**Hrs.**

available in laboratory. Results and Discussions: Determination of speeds of different wheels in gear train.	
Experiment No.2:- Verification of gyroscopic principle and determination of gyroscopic couple Aim & Objectives: To Verify experimentally the principles of Gyroscope. Outcomes: Able to describe effect of gyroscopic couple on various systems. Experimentation: Verification of active and reactive gyroscopic couples values using experimental setup. Results and Discussions: Calculation of active and reactive gyroscopic couples.	02 **Hrs.**
Experiment No.3:- Determination of M.I. using Bifilar and Trifilar suspension system. Aim & Objectives: To determine radius of gyration of rectangular bar using Bifillar and Trifillar suspension method. Outcomes: Able to determine radius of gyration of components. Experimentation: To determine value of Radius of gyration and M.I. of rectangular bar and Circular disc Experimentally. Results and Discussions: To verify the Radius of gyration and M.I. analytically and experimentally.	02 **Hrs.**
Experiment No. 4:- Determination of M.I. of connecting rod by Compound pendulum method. Aim & Objectives: To determine radius of gyration of connecting rod as Compound Pendulum. Outcomes: Able to determine radius of gyration and M.I. of components like Connecting rod. Experimentation: To determine value of Radius of gyration and M.I. of connecting rod Experimentally. Results and Discussions: To verify the Radius of gyration and M.I. analytically and experimentally.	02**Hrs.**
Experiment No. 5:- Experiment on Balancing of rotary masses (Static and Dynamic). Aim & Objectives: To observe the principles of static and dynamic balancing . Outcomes: Able to analyze rotary system for static and dynamic balancing. Experimentation: To arrange the given masses in Angular and linear positions for complete static and Dynamic balance. Results and Discussions: To find Angular and linear positions of masses analytically and to verify the results.	02**Hrs.**
Experiment No. 6:- Experiment on equivalent spring mass system. Aim & Objectives: To determine Natural Frequency of equivalent spring mass system. Outcomes: Able to determine Natural frequency experimentally. Experimentation: Determination of time period and natural frequency. Results and Discussions: Comparison between Analytical and Experimental natural Frequency.	02**Hrs.**
Experiment No.7:-Determination of logarithmic decrement for single DOF damped system Aim & Objectives : To determine logarithmic decrement for Torsionally vibratory	02**Hrs.**

system. Outcomes: Able to analyze effect of damping on vibratory system Experimentation: Plotting the logarithmic decrement of Torsionally vibratory system. Results and Discussions: Calculation of damping coefficient for vibrating systems.	
Experiment No. 8:- Experiment on study of forced vibration characteristics Aim & Objectives: To study effect of exciting force on characteristics of vibrations Outcomes: Able to determine forced vibration characteristics like Amplitude and Frequency. Experimentation: To plot the graph Amplitude vs Time for forced vibrations Results and Discussions: Determination of Maximum Amplitude and Natural Frequency for the Systems subjected to forced vibrations.	02**Hrs.**
Experiment No. 9:- Experiment on Whirling of Shaft Aim & Objectives: To study whirling of shafts Outcomes: Able to measure speed of shaft at which whirling takes place Experimentation: To measure speed of rotating shaft which is whirling. Results and Discussions: To measure critical speed of whirling.	02**Hrs.**
Experiment No.10:- Industrial visit based on above syllabus. Aim & Objectives : To make students acquainted to balancing of components like Gears, Pulleys used in Industry. Outcomes: Able to understand industrial procedure for Static and Dynamic Balancing. Experimentation: Demonstration of Measurement and removal of unbalance of Pulley using Balancing Machine.	02**Hrs.**

Textbooks:

1. Ratan S.S, "Theory of Machines", Tata McGraw Hill, New Delhi, 3rd Edition, 2011.
2. Sadhu Singh,"Theory of Machines", Pearson Education, 2nd Edition, 2009
3. H. G. Phakatkar,"Theory of Machines I", Edition 2009.Nirali Publication,5th Edition 2009.
4. Mechanical Vibrations by Grover G.K., Nemchand Publications.

References:

1. Hamilton H Mabie and Charles F Reinholtz, (1987), "Mechanisms and Dynamics of Machinery", Fourth Edition, John-Wiley and Sons, Inc., New York.
2. Ghosh A. and Mallick A.K., (1988), "Theory of Mechanisms and Machines", Affiliated East-West Press Pvt. Ltd., New Delhi.
3. William T Thomson, Marie Dillon Dahleh and Chandramouli Padmanabhan, (2004), "Theory of Vibration with applications", Fifth Edition, Pearson Education Publishers.
4. Theory of Machines by Dr. V.P.Singh, Dhanpat Rai Publications.
5. Theory of Machines by Ballaney, Khanna Publications.
6. Mechanical Vibrations by S.S.Rao, Pearson Education Publications
7. Theory of vibrations with applications by W.T. Thomson (CBS Publications)
8. Kinematics, Dynamics and Design of Machinery by Walidron, Wiley India Publi.
9. Theory of Vibration with applications by W.T.Thomson M.D.Dahleh.C.Padmanabhan Pearson Education

Title of the Course: Project Lab-II	L	T	P	Credit
Course Code:UMEC0508	0	0	2	1

Course Pre-Requisite: Basic sciences, Mechanical engineering science, Engineering Drawing

Course Description: This course provides an opportunity to students to work on real life problems related to identified course and to provide optimum solution to them. This approach is known as student's centric learning. Because of this way of learning, improvement in important process skills like problem solving ability, critical thinking, team working, communication skills and self learning abilities can be achieved.

Course Objectives:

1. To have a focus on long-term, multidisciplinary, and student-centered project-based learning activities.
2. To foster autonomous and collaborative learning by using resources to solve problems from the real world.
3. Possessing the ability to create software based on the principles of mechanical engineering, mostly by utilizing previously acquired information.
4. To gain hands-on experience in the specification, design, implementation, and testing phases of the mechanical system development life cycle.
5. To gain an ability to choose and use the proper mechanical engineering concepts while designing and evaluating a particular mechanical system.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to
CO1	IDENTIFY the real-world problems (related to identified multicourse level PBL) through a rigorous literature survey and formulate / set relevant aims and objectives
CO2	PROPOSE a suitable solution based on the fundamentals of mechanical engineering by possibly integration of previously acquired knowledge.
CO3	ANALYZE the results and arrive at valid conclusions
CO4	USE of technology in proposed work and demonstrate learning in oral and written form.
CO5	DEVELOP ability to work as an individual and as a team member.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P011	PO12	PSO1	PSO2	PSO3
CO1	2	1	1									2	2	2	2
CO2	2	2	2								2	2	2	2	2
CO3		2	2	1								2			
CO4					1			2		2		2			
CO5									2			2			2

Assessments :

Teacher Assessment:

Assessment	Marks
In Semester Evaluation (ISE)	25

ISE are based on multicourse level PBL Project assigned/Models preparation/ Presentation/ Group Discussion/ etc.

Course Contents:

Preamble:

Worldwide, engineering education is currently going through considerable structural changes.

The engineering curriculum must be regularly revised in light of emerging topics and with a multidisciplinary focus due to the fast changing technological landscape. In order to include these fresh themes into educational programs while maintaining the development of traditional abilities, it is required to develop, execute, and assess creative pedagogical approaches. In this setting, interest in project-based learning strategies is quickly growing across the educational community.

The typical classroom teaching method used in the majority of engineering programs places a strong emphasis on lectures and gives students little (if any) control over how they will learn. However, the rapid advancement of engineering and technology necessitates the adoption of a teaching strategy that would help students not only build a foundation of abilities relevant to their business, but also prepare them for future career choices.

Group Structure:

Working in supervisor/mentor –monitored groups. The students plan, manage and complete a task/project/activity which addresses the stated problem.

1. Create groups of 4-6 students in each class.
2. A supervisor/mentor teacher is assigned to 4-6 groups or one batch.

Project Selection:

Suitable project should be identified with respect to the problem statements related with identified ***multicourse level PBL courses. .(Dynamics of Machine and Machine Design)***

A survey of journal articles, patents, or a field visit can be used to choose the project. Problems can be theoretical, practical, social, technical, symbolic, cultural, or scientific. The issue must have the following components: an analysis of the issue, design and development of the system, and the viability of finding a solution (hardware or virtual).

It is advised to "learn by doing" in order to solve problem-based initiatives. The concept starts with the identification of an issue, which frequently develops from a query or "wondering." Then, this defined problem serves as the foundation for learning. Students' exploration of many academic fields and professional settings results in problems that can be theoretical, practical, social, technical, symbolic, cultural, and/or scientific in nature.

Ethical Practices, teamwork and project management:

Use Indian standards or any relevant standards for project manufacturing, respect the time of others, attend the reviews, poster presentation and model exhibitions, strictly follow the deadline of project completion, comply with all legislation requirements that govern workplace health and safety practices.

Guidelines for students:

Students should do survey and identify needs, which shall be converted into problem statement for mini project in consultation with faculty supervisor/head of department/internal committee of faculties.

- Students hall submit implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of mini project.
- A log book to be prepared by each group, wherein group can record weekly work progress, guide/supervisor can verify and record notes/comments.
- Faculty supervisor may give inputs to students during mini project activity; however, focus shall be on self-learning.
- Students in a group shall understand problem effectively, propose multiple solution and select best possible solution in consultation with guide/ supervisor.
- Students shall convert the best solution into working model using various components of their domain areas and demonstrate.
- The solution to be validated with proper justification and report to be compiled in standard Format.

Evaluation & Continuous Assessment

The comprehensive and ongoing monitoring and evaluation of student achievement is key to the PBL concept's effectiveness. It is recommended that regular reporting of all actions be mandated. Students must maintain a PBL log book at the department with regular evaluations of their PBL work. The following should be recorded in the PBL log book:

1. Student guidance and information
2. The PBL guide's weekly oversight,
3. Evaluation form for the PBL guide to review the PBL work

Recommended parameters for assessment, evaluation and weightage:

1. Idea Inception (kind of survey). (10%)
2. Documentation (Gathering requirements, design & modeling, implementation/execution, use of technology and final report, other documents). (15%)
3. Attended reviews, poster presentation and model exhibition. (10%)
4. Demonstration (Poster Presentation, Model Exhibition etc). (10%).
5. Awareness /Consideration of - Environment/ Social /Ethics/ Safety measures/Legal aspects. (5%)
6. Outcome (physical model/prototype/ virtual model/ product development/ assembly & disassembly and analysis of standard mechanism or system, design and development of small application, design of control systems, development of various systems/ /Hackathon/ application development and similar activities/ System performance and analysis) (40%)
7. Participation in various competitions/ publication/ copyright/ patent) (10%)

The review/ progress monitoring committee shall be constituted by head of departments of each institute.

The progress of mini project to be evaluated on continuous basis, minimum two reviews in each semester.

• In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.

• **Distribution of Term work marks for both semesters shall be as below;**

o Marks awarded by guide/supervisor based on log book : 10
o Marks awarded by review committee : 10
o Quality of Project report : 05

Project shall be assessed based on following points;

- ✓ Quality of problem and Clarity
- ✓ Innovativeness in solutions
- ✓ Cost effectiveness and Societal impact
- ✓ Full functioning of working model as per stated requirements
- ✓ Effective use of skill sets
- ✓ Effective use of standard engineering norms
- ✓ Contribution of an individual's as member or leader
- ✓ Clarity in written and oral communication

Reference Books / Research Articles:

1. John Larmer, John R. Mergendoller, and Suzie Boss, "Setting the Standard for Project Based Learning"
2. John Larmer and Suzie Boss, "Project Based Teaching: How to Create Rigorous and Engaging Learning Experiences" 3. Erin M. Murphy and Ross Cooper, "Hacking Project Based Learning: 10 Easy Steps to PBL and Inquiry".
3. Shinde,V.,(2014).Design of Course Level Project Based Learning Models for an Indian Engineering Institute: An assessment of students' learning experiences and learning outcomes .Institute for Planning, Aalborg University, 2014.
4. Vikas V Shinde and S S Inamdar. (2013). Problem Based Learning (PBL) for Engineering Education in India: Need and Recommendations. Wireless Peers Communication, 69, 1097-1105.

Title of the Course: Design of HAVC and Refrigeration system Course Code: **UMEC0601**	**L**	**T**	**P**	**Credit**
	3			**3**

Course Pre-Requisite: Applied Thermodynamics, Fluid Mechanics, Heat & Mass Transfer.

Course Description:

This subject enables the student to understand refrigeration cycles, their analysis and performance evaluation. Students will learn different refrigerants, their properties. The students will also learn components of refrigeration systems.

Course Objectives:

1. Study basic refrigeration cycles and Psychrometry
2. Performance Evaluation of Refrigeration and Air Conditioning Systems
3. Enable the students to analyze and solve refrigeration related problems by applying principles of mathematics, science and engineering.
4. To develop a professional approach to lifelong learning in the refrigeration/ air conditioning

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	**Bloom's Cognitive**	
		level	**Descriptor**
CO1	Apply knowledge of mathematics, science, and engineering for the needs in refrigeration and air conditioning.	3	Applying
CO2	Analyze different refrigeration and air conditioning systems with their applications.	4	Analyse
CO3	Evaluate refrigeration and air-conditioning systems under different conditions.	5	Evaluate

CO-PO Mapping:

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3												3		
CO2	3	2												2	2
CO3		2		3	3										

Assessments:

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1: **Basic Refrigeration Cycles:** Carnot cycle, Reversed Carnot cycle, Simple Vapor compression cycle, effect of subcooling, suction vapor superheating, Liquid to suction vapor heat exchanger, Calculations and performance of above cycles, Actual vapor compression cycle, Bell Coleman - Reversed Bryton cycle, Air cycles for aircrafts (Descriptive Treatment). **Multi pressure System:** Removal of flash gas, Flash inter-cooling, Water-cooling, Multistage, Multi-evaporator and Cascade System. .	**7 Hrs.**
Unit 2. Multi pressure System and Refrigerants: **Refrigerants:** Classification, Desirable Properties like Thermodynamic, physical and chemical. Comparison among commonly used refrigerants, Selection of Refrigerants, Effect on Ozone depletion and global warming, Alternative Refrigerants. Secondary refrigerants. **Vapor Absorption System:** Aqua Ammonia system, Enthalpy-Concentration chart, analysis of system. Lithium Bromide -water vapor absorption system, Coefficient of Performance, Comparison with Vapor Compression cycle. (Descriptive treatment only).	**6 Hrs.**
Unit 3: Cryogenics and Vapor Absorption System: **Cryogenics:** Introduction to cryogenic engineering and application, liquefiers and cryocoolers. Cryogenic systems and applications	**7 Hrs.**
Unit 4: Refrigeration Equipment & System Design : Types of Compressor, Condenser, Evaporator, Expansion devices, and selection, different controls and accessories, use of insulation, its types and applications. **Design of refrigeration systems -** Household refrigerator, Ice plant, Cold storage, refrigerated vehicle, Water Chiller.	**6Hrs.**
Unit 5: Psychrometry: Moist air as a working substance, Psychrometric properties of air, use of Psychrometric tables and charts, processes, combinations and calculations, ADP, Coil condition line, sensible heat factor, bypass factor, air washer and it's applications. Comfort: Thermal exchange between human body and environment, factors affecting comfort, effective temperature, comfort chart, ventilation requirements.	**7 Hrs.**
Unit 6: Heating and Cooling Load Calculation: Representation of actual air conditioning process by layouts and on Psychrometric charts, load analysis1, GSHF, ESHF, Enumeration and brief explanation of the factors forming the load on refrigeration and air conditioning systems, Energy requirements of different types of air conditioning systems, Energy conservation in air conditioning **Design Analysis of Air Conditioning System:** Design of Air conditioning systems: Design considerations, Load calculations, Single unit room air-conditioner, Central air conditioning plant, Industrial drying systems,	**8Hrs.**

Component selection.	

Textbooks:

1. C. P. Arora ,"Refrigeration and Air conditioning", Tata McGraw Hill Education Private Limited , third edition,2008
2. Roy J. Dossat "Principles of Refrigeration", Pearson, fourth edition, 2007.
3. Stoecker & Jones, "Refrigeration and Air-conditioning", McGraw Hill Book Company, New York, 1983.
4. Dr. S.N. Sapali "Refrigeration and Air-conditioning", PHI (Second Edition) 2016

References:

1. Wilbert F. Stoecker, Industrial refrigeration handbook, 1st edn., McGraw-Hill Professional Publishing,1998
2. Shan K. Wang, "Handbook of air conditioning and refrigeration" McGraw-Hill international edition, second edition.
3. ASHRAE Hand Books

Unit wise Measurable students Learning Outcomes:

Students should be able to:

1. Describe and recall basics of thermodynamics and study and analyze refrigeration cycles.
2. Carry out performance study of multistage VCC. Classify the refrigerants; explain the physical, chemical properties of refrigerants.
3. Study the applications of cryogenic systems. Analyze vapor absorption system.
4. Select different equipment used in refrigeration and become familiar with application of refrigeration.
5. Describe and recall basics of thermodynamics and air conditioning.
6. Calculate heating and cooling load for air conditioning systems.

Title of the Course: Power Plant Engineering Course Code:UMEC0602	L	T	P	Credit
	3	-	-	3

Course Pre-Requisite: Applied Thermodynamic, Basic Mechanical Engineering, Heat Mass Transfer.

Course Description:

The aim of this course is to provide students with a working knowledge and application of the fundamentals of how the operation of power plant affect their working, performance, fuel requirements and environmental impact.

The focus is on explaining engine performance in terms of power, energy utilization and exhaust emissions, its relation to internal processes like combustion and gas exchange at varying engine-operating condition.

Course Objectives:

1. To enable the students to analyze the Ideal and actual air standard cycles and valve timing diagrams.
2. To make the students to study of fuel supply system in I.C. Engine.
3. To educate the student about combustion phenomenon and emission characteristics of engines.
4. To impart knowledge about various engine performance characteristics of engine.
5. Comprehend the different technological advances in engines and alternate fuels.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Explain fundamentals of I. C. Engine	II	Understanding
CO2	Classify different systems if I. C. Engine	II	Understanding
CO3	Measure performance parameters of power plants.	III	Applying
CO4	Estimate Performance and operational characteristics of power plants	IIII	Evaluating

CO-PO-PSO Mapping:

CO	PO1	PO2	PO3	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3											2		
CO2	3						2	2						
CO3		3											2	
CO4		3												

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.	
Course Contents:	
Unit 1:--- Introduction Introduction, Classification of Power plants, applications, Engine specifications. Engine Cycles: Engine cycles, Deviation of actual cycles from air standard cycles, Valve timing diagram for high and low speed engine, Port timing diagram. Working of Supercharging and Turbo-charging, Introduction to Alternative fuels.	**05 Hrs.**
Unit 2: Fuel Supply system for SI and CI Engine **Fuel Systems for S.I. Engines:** Engine fuel requirements, complete carburetor, Derivation for calculation of A/F ratio, Calculation of main dimensions of carburetors, Effect of altitude on Air fuel ratio. Electronic Petrol injection system (MPFI). **Fuel Systems for C.I. Engines:** Requirements of injection system, Types of injection systems – Individual pump, Common rail and Distributor systems, Unit injector, Types of fuel nozzles- single hole, multi hole, pintle, and pintaux. Governing of C.I. engines. Electronic diesel injection system. Calculations of main dimension of fuel injection system.	**09 Hrs.**
Unit 3:--- Performance Testing of I. C. Engine Performance parameters, Measurement of performance parameters like torque, power, Volumetric Efficiency, Mechanical Efficiency, BSFC, Brake and Indicated Thermal efficiencies. Numerical on Heat Balance Sheet and engine performance, Performance curves.	**06 Hrs.**
Unit 4:--- Combustion & Emission control Stages of combustion in S.I. and C.I. engine, Knocking in S.I. and C.I. engine, types of combustion chamber in S.I. and C.I. engine. S.I. engine emission (HC, CO, NOx) Control methods- Evaporative (ELCD), Thermal, Catalytic converters, C.I. Engines Emission (CO, NOx, Smog, Particulate), Control methods- Chemical, EGR, Standard pollution Norms like EURO, Bharat stage. Pollution monitoring instruments, Pollution measuring and control devices.	**08 Hrs.**
Unit 5:--- Resources and development of power in India- NTPC, NHPC and their role in Power development in India, Indian Electricity Grid Code, Present Power position in India and world. Different types of power plants – Thermal, Hydro, Gas Turbine, Nuclear and their characteristics, Comparison of Power plants with respect to various parameters, Combined Cycle, MHD - steam plant., Pumped storage, Compressed Air storage power plants and their characteristics.	**06 Hrs.**
Unit 6:--- Economics of Power Plant- Load Curves and Load duration curves (Numerical 7Hrs treatments), Performance and operational characteristics of power plants, Peak load,	**06 Hrs.**

Intermediate load and Base load plants and their characteristics, Input output characteristics of power plants, Economic division of between Base load plant and peak load plants, Tariff methods, Cost of electric Energy, Fixed and operating cost	

Textbooks:

1. A Course in Power Plant Engineering, S.C. Arora and S. Domkundwar, Dhanpat Rai, 1988
2. A Text Book of Power Plant Engineering, R. K. Rajput, Laxmi Publications, New Delhi.
3. Internal Combustion Engines", V. Ganesan, Tata McGraw Hill Publication.
4. "Internal Combustion Engines" Mathur and Sharma, Dhanpat Rai Publication , Delhi.
5. "Internal Combustion Engines",R. K. Rajput, SciTech Publication.
6. Solar Energy, Sukhatme, 3rd Edition, Tata McGraw-Hill Education, 2008
7. Fundamentals of Renewable Energy Resources, G. N.Tiwari and M. K. Ghosal, Narosa Publishing House, 2007

References:

1. "Internal Combustion Engines", J. B. Heywood,Tata McGraw Hill Publication .
2. "Internal Combustion Engines",Maleev, CBS Publication and Distributors.
3."Internal Combustion Engines",Gills and Smith, Oxford and IBH Publishing Company
4. "Internal Combustion Engines Fundamentals", E. F. Obert, Harper and Row Publication , New York.
5. Renewable Energy Resources, John Twidell & Anthony D. Weir, 2nd Edition, Taylor & Francis, 2006
6. Power Plant Engineering, P.K.Nag, 2nd Edition, Tata McGraw-Hill Education, 2002

Unit wise Measurable students Learning Outcomes:

1. Describe the contractional detailing of IC engines and analyze the Ideal and Actual cycle.
2. Understand the working of fuel supply system for SI and CI engine.
3. Plot performance characteristics curve during testing and prepare a performance report.
4. Analyze various stages of combustion & emission in engine.
5. Study different types of power plants.
6. To provide the knowledge about present power scenario in India.

Title of the Course: MECHATRONICS SYSTEM	L	T	P	Credit
Course Code: UMEC 0603	3	-	-	3

Course Pre-Requisite: Knowledge of basic Electronics and Electrical Engineering.

Course Description: Studying the mechatronics course is of importance due to the global demand and developments in Mechatronic systems, Industry 4.0 and automated manufacturing planning and controlling activities etc. The mechanical systems are becoming smart and for designing and developing such smart systems students of mechanical engineering must understand basic elements of smart systems such as sensors, signal conditioning devices, microcontrollers, digital logic and programs for automating the processes.

Course Learning Objectives:

CLO1: To learn various concepts of automation, Mechatronics and PLC and the integration of different branches of engineering in Mechatronics.

CLO2: To prepare graduates of mechanical engineering with comprehensive knowledge of Mechatronics to enable them to apply the relevant knowledge and technologies for the design and realization of innovative systems and products.

CLO3: To prepare Mechanical Engineering students for advanced graduate studies in Mechatronics, Manufacturing engineering and related field.

Course Learning Outcomes:

CO	After successful completion of the course the student should be able to	Bloom's Cognitive level	Bloom's Cognitive Descriptor
CO1	**Summarize** components and applications of Mechatronics systems along with key concepts related to Industry 4.0.	II	Understanding
CO2	**Explain** the various concepts related to different microcontrollers used in mechatronic systems.	II	Understanding
CO3	**Solve** scenarios of automating the processes using the PLC programming approach.	III	Applying

CO-PO,PSO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1	1									1	1	1
CO2	2	1	1	2	1								1	1	2
CO3	2	3	3	1	2								2	2	2

1: Low 2: Medium 3: High

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Components	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with 60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:	Hours
Unit 1: - Mechatronics Systems Definition of Mechatronics, Mechatronics advantages and its applications, Mechatronics systems, Components of Mechatronic Systems, Multi-discipline scenario, Traditional Vs Mechatronic Design, Case studies of Mechatronic systems designs, Introduction to SCADA and MEMS and its applications.	**06**
Unit 2: - Digital Circuits and Microcontroller Digital logic, Number systems, Logic gates, Boolean algebra, Application of logic gates, Sequential logic, Flip flop, D flip flop, JK flip flop, Master-slave flip flop**.** Introduction to Microcontroller, Comparison between microprocessor and microcontroller, Organization of a microcontroller system, Architecture of 8051, Pin diagram of 8051, Addressing modes, Instruction types and set, Selection and Applications of Microcontroller.	**07**
Unit 3: - Modern Microcontrollers: Introduction to Arduino, Types of Arduinos, Introduction to Arduino UNO, Arduino UNO board breakdown, Prototyping environment, Arduino Integrated Development Environment (IDE), setting up Arduino board, Arduino Pin Diagram, Sample Circuits, creating sketches, basic Programming, introduction to the Raspberry	**07**

Pi board, comparison of Arduino board with Raspberry Pi board, IoT implementation using Arduino.	
Unit 4: - Programmable Logic Controllers (PLC) Introduction, Definition, PLC system and components of PLC Input-output module, PLC advantages and disadvantages. Ladder diagram and PLC programming fundamentals: Basic components and other symbols, Fundamentals of ladder diagram, Machine control terminology, Instruction list, Update – Solve ladder – Update, Physical components Vs. program components, Light control example, Internal relays, Disagreement circuit, Majority circuit, Oscillator, Holding (sealed or latches) contacts, Always ON always OFF contacts, Nesting of ladders. **PLC Communication Services** – Protocol- Definition, Networks, Nodes, and Topologies, Communication Methods, Deterministic and Non deterministic bus system, Control Protocols.	**08**
Unit 5: - PLC Functions **Timers in PLC**– Introduction, Delay On Timer, Delay OFF Timer, Retentive Type Timer on Delay, Cascading of Timers, industrial application of Timers. **Counters in PLC**– Introduction, Up Counter, Down Counter, industrial application of Counters Fault finding and troubleshooting of PLC.	**06**
Unit 6: - Industry 4.0 **Introduction:** Smart Manufacturing for Industry 4.0, An example of a smart manufacturing system for Industry 4.0, Timeline of Industry 1.0–4.0. **Technologies in Industry 4.0:** Big Data, Cloud Manufacturing, Internet of Things, Autonomous Robots, Simulation, Horizontal and Vertical Systems Integration, Cyber Security, Additive Manufacturing, Augmented Reality, The Smart Factory of the I4.0, Cyber-Physical Systems, Internet of Services.	**06**

Text books:

1. Mechatronics", W. Bolton, Pearson Education, 4th Edition.
2. Mechatronics", Mahalik, TATA McGraw Hill, (2006) Reprint,
3. "Microprocessor 8085", Gaokar Prentice Hall of India, 5th Edition.
4. "The 8051 Microcontroller -A System Approach", by Muhammad A. Mazidi, 1st Ed., PHI
5. "Industry 4.0: Managing The Digital Transformation", by Alp Ustundag, Springer Publication
6. "Introduction to PLC Programming" NIIT.
7. "Programmable Logical Controller", Hackworth, Pearson Education, (2008).
8. "Programmable Logical Controller", Reis Webb, Prentice Hall of India 5th Edition.
9. "MEMS and Microsystems", HSU Tairan, TATA McGraw Hill Publication. 1st Edition.

References:

1. Mechatronics",Appu Kuttam, Oxford Publications, 1st Edition.
2. "Automated Manufacturing Systems", S. Brain Morris, Tata McGraw Hill.
3. "Mechatronics and Microprocessor", Ramchandran , Willey India, (2009).
4. "Mechatronics: Integrated Mechanical Electronic System", Ramchandran , Willey India,1st Edition.
5. "Programmable Logical Controller", Gary Dunning Cengage Learning, 3rd Edition.
6. "Programmable Logic Controllers and programming concepts", Joji Parambath.
7. "Mechatronics Source Book", N C Braga, Cengage Learning.
8. "SCADA", Stuart A. Boyer, ISA Publication, 4th Edition.

Unit wise Measurable students Learning Outcomes:

1. Graduates will be able to aware of advances and different case studies in the field of mechatronics and automation.

2. Graduates will be able to explain different aspects of Microcontroller and its architecture, instructions, comparison, applications.

3. Graduates will be able to study of various aspects advance microcontrollers.

4. Graduates will be able to identify different components of PLC and can perform simple ladder diagram programming by knowing the rules of a drawing ladder diagram, inputs, outputs, timers, counters.

5. Graduates will be able to develop PLC programs for various simple applications.

6. Graduates will be able to explain key components and technologies used in Industry 4.0 and Smart manufacturing.

Title of the Course: Control Systems	L	T	P	Credit
Course Code:UMEC0604	**2**	**-**	**-**	**2**

Course Pre-Requisite: There are no formal prerequisites for this course; however you will need some knowledge of material from the following courses: physics, mathematics and electrical engineering.

Course Description: This course provides an introduction to linear systems, transfer functions, and Laplace transforms. It covers stability and feedback, and provides basic design tools for specifications of transient response.

Course Objectives:

1. Understand different dynamic systems and to be able to model such systems. This assists in understanding the wider implications of these engineering concepts, including responsibility in social, cultural and environmental issues
2. Understand the concept of feedback and how it influences the response of a system.
3. Understand the response of a dynamic system to an input signal and to be able to predict the response of a particular system. This applies the mathematical and engineering sciences, including physics, to real-life problems.
4. To synthesize and demonstrate the efficacy of solutions to part or all of complex engineering problems, including formulating models from first principles of engineering science and mathematics

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Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Understand and Construct models of physical systems in forms suitable for use in the analysis and design of control systems.	6	Create
CO2	Make use of block diagram reduction, signal flow Technique and state space to represent control system	3	Applying
CO3	Identify the time domain responses of first and second-order systems to inputs like step, impulse etc.	3	Applying
CO4	Sketch root locus and analyze time domain control system	4	Analyze

CO-PO-PSO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	PO11	PSO1	PSO2	PSO3
CO1	3	2												
CO2	3	2												
CO3	2	2	2										2	
CO4	2	3	2	3										

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Components	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.

MSE: Assessment is based on 50% of course content

ESE: Assessment is based on 100% course content with 60-70% weightage for course covered after MSE.

Course Contents:

Unit 1: Basic Elements and Mathematical Modeling of Control System Classification of control system: Open loop and Closed loop systems, Linear-non linear, SISO-MIMO, etc. Advantages and limitations of open loop and closed loop systems and its applications. Modeling of Electric systems, Translational and rotational mechanical systems	8-- **Hrs.**
Unit 2:--- Control system representation: Block diagram Algebra, Signal flow graph reduction using mason's gain formula. State space representation-concept of state, state variables and state model	7-- **Hrs.**
Unit 3:--- Time Response Analysis: Time response of first order systems for impulse, step inputs, Transient response of second order systems for unit step input. Time domain specifications. Steady state Error and Error Constants .	8-- **Hrs.**
Unit 4:--- Stability & Root Locus Analysis: Stability criterion-Routh's stability. Root Locus-significance and Construction. Effect of addition of Poles and Zeros.	7-- **Hrs.**

Textbooks:

1 .Control System Engineering", R Anand Natarajan, P. Ramesh Babu, SciTech Publication, 2nd Edition.

2"Control Systems" ,A. Anand Kumar, Prentice Hall Publication.

3"Automatic Control Engineering", F.H. Raven Tata McGraw Hill Publication, 5th Edition.

4 "Feedback Control Systems", R.A.Barapte, Tech-Max publications.

References:

1. Modern Control Systems", K Ogata, , Prentice Hall Publication ,3rd Edition.
2. "Automatic Control Systems", B.C. Kuo, Willey India Ltd. / Prentice Hall Publication, 7th Edition.
3. "Automatic Control Engineering", D. Roy and Choudhari, Orient Longman Publication Calcutta.
4. "Modern Control Engineering", K. Ogata, Pearson Education

Unit wise Measurable students Learning Outcomes:

- Derive equations to model the dynamics of simple system.
- Draw block diagrams and signal flow graphs and state space models to represent different control systems.
- Use Laplace Transforms to derive transfer functions.
- Represent state space model to analyze control systems.
  Construct and use Roots' Loci diagrams to characterize simple dynamical systems.

Title of the Course: MECHANICAL VIBRATIONS Course Code: UMEE0621	L	T	P	Credit
	03	-	-	03

Course Pre-Requisite: Basics of mathematics, physics, Analysis of Mechanical Elements, Dynamics of Machines

Course Description: Many practical applications need investigation of Vibration such as machines, engines, turbines, structures, etc. Study of vibration is necessary to improve performance of system and to optimize the system at both design stage and application stage.. The subject contains - Introduction to vibration. Two degree of freedom systems, Multi degree vibrations. Numerical methods for multi degree vibration analysis, vibration measurement and condition monitoring, and introduction to Noise effects and measurement.

Course Objectives:

1. To take overview of basic concepts of vibration analysis.
2. To study vibration analysis of two and multidgree of freedom systems
3. To acquaint students with the principles of vibration measuring instruments and condition monitoring.
4. To acquaint students with noise measurement and its control.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Explain fundamentals of vibration and noise in mechanicalsystems.	II	Understanding
CO2	Solve numerical of natural frequency of mechanical system.	III	Applying
CO3	Analyze vibratory response of mechanical system.	IV	Analyze
CO4	Develop mathematical model to represent dynamic system .	V	Design

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	PO11	PO12	PSO1	PSO2	PSO
CO1	3											3	2		
CO2	2	3	1									2	1	2	
CO3	2	2	2	2	1							1	1	1	1
CO4		3	2	1										1	2

1:low, 2: medium, 3:high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:- Introduction to vibrations - Overview of types of vibrations, overview of analysis of vibrations - Free, forced, damped and undamped vibration of single degree of freedom systems	04 **Hrs.**
Unit 2:- Two Degrees of Freedom: Principal modes and natural frequencies of two DOF systems (spring-mass, pendulum, two rotor, etc.) Co- ordinate coupling and principal co-ordinates. Harmonic excitation, Vibration Dampers and absorbers, Dynamic vibration absorber – Tuned and Un tuned type.	08 **Hrs.**
Unit 3:- Introduction to Multi degrees of Freedom : Free vibrations of Multi DOF System-Flexibility and stiffness influence coefficient, Equation of motion , Rayleigh's method, Matrix iteration method , Holzer method. Introduction to non linear vibrations.	08 **Hrs.**
Unit 4:- Vibration Measurement and Applications : Instruments for measurement of displacement, velocity, acceleration and frequency of vibration, Sensors and Actuators, signal conditioners, Time and frequency domain plot, Spectral analyzers, Exciters, FFT analyzer.	06**Hrs.**
Unit 5 – Basics of Noise : Basic definitions, human response to sound, Decibel scale, Relation among sound power, Sound intensity and sound pressure level, Octave Band Analysis, Noise-Effects, Rating and regulation Non auditory and Auditory effects of noise,Noise standards and limits, Ambient emission noise standards in INDIA, Hazardous noise explosion, Day night noise level.Noise measurement and control	07**Hrs.**

Unit 6 – Condition Monitoring and Fault Diagnosis : data acquisition – time domain and frequency domain, signal analysis and data filtering, Vibration and noise monitoring, vibration analysis of rotating elements – bearing, gear, fan/blower, pump, IC engine, Motor current signature analysis, wear debris and oil analysis.	07**Hrs.**

Textbooks:

1. "Mechanical Vibrations", Singiresu S.Rao , Pearson Education,
2. "Mechanical Vibrations", G. K. Grover, Published by Nemchand and Brothers, Roorkee.
3. "Mechanical Vibrations", Dr. V. P. Singh, Published by S. Chand and Sons New Delhi.
4. "Noise and Vibration Control", Leo L. Bernack, Tata Mc- Graw Hill Publication.
5. "Mechanical Vibration and Noise Engineering",A. G. Ambekar, Prentice Hall of India.
6. "Fundamentals of Vibrations", Balchandran Magrab ,Cengage Learning.
7. "Theory of Vibrations with Applications", W. Thomson, Pearson Education,2nd Edition.
8. "Machinary Condition Monitoring: Principles and Practices, A.R.Mohanty,CRC Press, 2014

References:

1. "Mechanical Vibration",Austin Church, Wiely Eastern. 2nd Edition.
2. "Schaumm's Outline series in Mechanical Vibration", S. Graham Kelly, 6th Edition.
3. "Kinematics, Dynamics and Design of Machinery",Waldron, Willey India, 2nd Edition.
4. "Mechanical Vibrations", J.P. Den Hartog, Tata McGrawhill Book Company Inc., 4th Edition.
5. "Introduction to Dynamics and Control", Leonard Meirovitch, J. Wiley, New York.
6. "Elements of Vibration Analysis" Leonard Meirovitch, Tata McGrmv-Hill, New York. 2nd Edition.
7. "Principles of Vibration",Benson H. Tongue,Oxford University Press., 4th Edition.
8. "Vibrations and Noise for Engineers", Kewal Pujara Dhanpat Rai and Sons, (1992).
9. "Mechanical vibration", William J Palm III Wiley India Pvt. Ltd., ISBN 978-81-265-3168-4, 1st Edition.
10. "Fundamentals of vibrations", Leonard Meirovitch, McGraw Hill International Edition.
11 "Principles of Vibration Control", . Asok Kumar Mallik, Affiliated East-West Press.
12 "Mechanical Vibrations", A.H. Church, John Wiley and Sons, Inc, New York, 1994.

Unit wise Measurable students Learning Outcomes:

1. **Identify types of vibratory system as Undamped, Damped, SDOF, MDOF**
2. **Model the vibratory system for analysis purpose.**
3. **Evaluate natural frequencies and mode shapes of two DOF systems.**
4. **Evaluate natural frequencies and mode shapes of MDOF systems.**
5. **Measure the vibration parameters of system using instruments.**
6. **Understand the terms related to acoustic and measure the noise level.**

Title of the Course: Advanced Automobile Design	L	T	P	Credit
Course Code: UMEE0622	3	-	-	3

Course Pre-Requisite: -- basics Knowledge of 'Fundamentals of Automobile Design (Ready Engineer Part -I)', CAD, General Design procedure is essential.

Course Description: The course covers some of the practical & real-world design aspects for automobiles, specially for body-in-white (i.e. structures) and trims (i.e. interiors). This is one of the unique and highly advanced courses prepared by over 20 senior experts of TATA TECHNOLOGIES, PUNE working on multiple national and international projects of whole-vehicle development. The course is intended to provide an edge to the engineering students seeking career in design domain.

Course Outcomes (CO):

CO	After the completion of the course the student should be able to	Bloom's* Cognitive level	Bloom's* Cognitive Descriptor
CO1	**Identify** commodities of BIW & trims and Explain the concept of Product life cycle	3, 2	Identify Explain,
CO2	**Recommend** appropriate material for BIW and Trims considering material properties which satisfy the requirements	5	Recommend
CO3	**Illustrate** the concept of GD&T for BIW, sheet metal joining processes and plastic parts manufacturing processes	2	Illustrate
CO4	**Explain** the concept and methodology of DFMEA and CAE and **Select** appropriate element for given application	2, 3	Explain Select
CO5	**Identify** appropriate CAE method to carry out various BIW and Trims analysis	3	Identify
CO6	**Explain** various types of physical vehicle testing and various steps involved in assembly of car on assembly line	2	Explain

CO-PO* Mapping:

CO	1	2	3	4	5	6	7	8	9	10	11	12
CO1	1	1										2
CO2	3	3										2
CO3	3											2
CO4	3	2		2	3							2
CO5	3	2		2	3							2
CO6	2	1	2	2	1							2

Assments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with 60-70% weightage for course

content (normally last three modules) covered after MSE.	
Course Contents:	
Unit 1:--- Requirement Specification in the Pre-Program Stage: a) Introduction to BIW. Identification of commodities for BIW: Closures, Body Shell. BIW terminology. BIW Assembly. b.) Introduction to Plastic trims. What is trim? Necessity of trim in automobile, Identification of various trim parts and their positions in vehicle. Various commodities of interior trim like Instrument panel, Centre console, Door trims, Pillar Trims, Seating Trims, Overhead Trims, Floor Carpets & Trunk trims. **c)** Introduction to preprogram stages like voice of customer, competitor insight, innovation, Project and quality planning, legislation. A, B, C surfaces, CAS vs Class -A surfaces, Bazier Curves, Types of continuities. **d) Product life cycle and important gateways for BIW**: Definition of PLM. Product life cycle: Design milestones, Types of builds, Launch of Vehicle. Flow chart of PLM, Design gateways: Design phases like virtual build, Prototype build, Mass Production. Launch of Vehicle	6 **Hrs.**
Unit 2: BIW and TRIM Design and Materials a) **Design concepts and considerations in BIW**: BIW parts: Sheet metal, Extrusion, Cast, Moulding. Factors driving BIW Design like Package Space, Master Sections, Cost, Weight, Assembly Process, Manufacturing Methods, Vehicle regulations. Design considerations for Sheet Metal Parts for 1. Manufacture, 2. Assembly and Part location on a vehicle. b) **BIW Materials and Grades** (Steel, Aluminium, composites): Evolution of automobile to modern Design. Basic material selection criteria for automotive: Emissions, Safety and weight, Material Choice which is driven by Cost, Safety, Risk, Weight, Market Image, Emission. Classification of steel grade and their properties. Use of aluminium in automotive domain and its properties. Use of Composites in automotive domain and its properties. Light weight material for future automotive industry. c) **Trim Materials in Automotive**: Material Classification and Properties, Plastic Material and their applications: Polypropylene, ABS, Polycarbonate, Polyoxymethylene, Polyethylene, Polyamides, Usage and Selection Criteria, Plastic Additives: Types of additives, Impact of additives, , Application in instrument Panel Assembly.	7 **Hrs.**
Unit 3: GD & T for BIW: **b)** Concept of GD & T, Importance of GD&T. International standards for GD&T like BS, ASME, ISO. Role of GD & T on drawing, BIW Dimensional Requirement. BIW Dimensional applications. GD&T Symbols. 3-2-1 Principle. Types of locators. Principles of location. Illustration of Feature Control Frame. BIW Examples and case studies. **a) Sheet Metal Joining Process:** Importance. Welding, Resistant Spot welding: Advantages, Disadvantages of RSW. Concept of Tailor Welded Blanks(TWB), Types of TWB. Laser Beam Welding (LBW): Types, Advantages, Disadvantages. Self Piercing Rivets (SPR) and its advantages. Adhesive Bonding: Types, Types of joints used in it. **c) Manufacturing Processes of plastic trim:** Vacuum Forming, Injection Molding, Heat Staking, Extrusion Blow molding along with their applications characteristics and limitations.	6 **Hrs.**

Unit 4: DFMEA & CAE **DFMEA** (Design Failure Mode and Effect Analysis): Concept, Objectives of DFMEA. Over view of DFMEA process, Benefits of DFMEA, Prerequisites of DFMEA, DFMEA Flow, DFMEA team, DFMEA inputs & Outputs, DFMEA Methodology, **Design of Plastic part:** Overview, Wall thickness, Radii, Draft angle, Ribs, Bosses, Snaps, **b)** Introduction to Design Verification: Concept of Design Verification. Process of verifying Design. Commonly used verification methods like Demonstration, Inspection, analysis, Similarity, Testing. Preparation of verification activities. Conducting verification activities. Gateway support for Design verification. **c)** Concept of CAE, Applications of CAE, Various CAE methods for Design verification of BIW viz. Structural Analysis, Fatigue life Prediction, Noise and vibration, Crash Impact analysis, Multibody Dynamics, Thermal analysis, CFD. Verification and Validation with respect to FEA. Concept of FEA, Steps of FEA, meshing, Elements: Selection and its types.	7 **Hrs.**
Unit 5: CAE ANALYSIS **a) CAE Analysis of BIW: -** Concept of Load Case, NVH Analysis: Load cases for NVH analysis: Static Bending stiffness, Static torsion stiffness, Natural frequency and normal modes, , CAE Crash Analysis: 1) Full vehicle level: Frontal, Side and rear Impact, 2) Component Level: Seating and roof crush., Durability analysis: Various load cases like Front and Rear Recovery analysis, Trailed towing analysis, Floor pan fatigue, Roof and Body side oil canning, Vehicle jacking analysis, Vehicle hoisting analysis, Fatigue analysis of BIW. **CAE Analysis OF Plastic Trims:.** Types of CAE Analysis: Head Impact Analysis, Side Impact Analysis, Knee Impact Analysis, Durability Analysis, Creep Analysis, Moldflow Analysis. Applications of CAE Analysis**.** CAE Load cases for Interior Trims: Airbag deployment, Side occupant protection, Interior trims durability, Mold flow analysis. Gateway support.	6 **Hrs.**
Unit 6:- Test Validation & Assessment **:** Crashworthiness, Head Injury Criteria, Vehicle physical testing, Need of vehicle testing, Crash test requirements, Introduction to dummies, Importance of Dummies, Types of dummies. Frontal Crash test, Rear and side impact testing, Side Pole Impact Test, Pedestrian head impact test, roll over test. Four post durability test. Wind tunnel testing. Automotive safety considering plastic components, NCAP, BHARAT NCAP, Active Safety and Passive safety features in modern passenger vehicles. Future trends in BIW, BIW for EV, **Manufacturing -** Sequence (after validation):, Welding & Assembly: Body shop, Paint Shop, Trim- chassis.	6 **Hrs.**

Unit wise Measurable students Learning Outcomes:

1. To **Identify** commodities of BIW & trims and Explain the concept of Product life cycle.
2. To **Recommend** appropriate material for BIW and Trims considering material properties which satisfy the requirements.
3. To **Illustrate** the concept of GD&T for BIW, sheet metal joining processes and plastic parts manufacturing processes.
4. To **Explain** the concept and methodology of DFMEA and CAE and **Select** appropriate element for given application

5. To **Identify** appropriate CAE method to carry out various BIW and Trims analysis
6. To **Explain** various types of physical vehicle testing and various steps involved in assembly of car on assembly line

Textbooks:

1. Morello, L., Rosti Rossini, L., Pia, G., &Tonoli, A. (2010). *The Automotive Body: Volume I: Components Design (Mechanical Engineering Series)*. Retrieved from http://www.springer.com/1161---A2
2. Huang, M. (2002). *Vehicle crash mechanics*. CRC Press.-A2
3. Failure Mode and Effect Analysis: FMEA from Theory to Execution, D. H. Stamatis, ASQ Quality Press, 2003, 0873895983, 9780873895989.
4. IGETIT PORTAL OF TATA TECHNOLOGIES.

REFERENCE BOOKS:

1. Boljanovic, V. (2004). *SHEET METAL FORMING PROCESSES AND DIE DESIGN*. A1 and A2
2. Weber, J. (2009). *Automotive development processes: Processes for successful customer oriented vehicle development*. *Automotive Development Processes: Processes for Successful Customer Oriented Vehicle Development*. Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-01253-2--A2
3. *An Introduction to Modern Vehicle Design*. Edited by Julian Happian-Smith,© Reed Educational and Professional Publishing Ltd 2002—A2
4. *Automotive Product Development*. A Systems Engineering Implementation, by Vivek D. Bhise,© 2017 by Taylor & Francis Group, LLC CRC Press is an imprint of Taylor & Francis Group, an Informa business.—A2
5. Design and Manufacture of Plastic Components for Multifunctionality. (2016). In *Design and Manufacture of Plastic Components for Multifunctionality*. https://doi.org/10.1016/c2014-0-00223-7-A2
6. Effective FMEAs: Achieving Safe, Reliable, and Economical Products and Processes using Failure Mode and Effects Analysis,Carl Carlson,ISBN: 978-1-118-00743-3 June 2012.
7. Schwartz & Goodman “Plastic materials and Processing”
8. Irwin Rubin, “Handbook of plastic materials and technology”
9. Fred W. Billmeyer, “Textbook of Polymer Sciences”.

Title of the Course: COMPUTATIONAL FLUID DYNAMICS Course Code: UMEE0623	L	T	P	C
	3	-	-	3

Course Pre-Requisite: Fluid Mechanics, Heat Transfer, Elementary Numerical Analysis, ODE, PDE

Course Description:

Computational fluid dynamics (**CFD**) is a branch of fluid mechanics that uses numerical analysis and data structures to solve and analyze problems that involve fluid flows. Computers are used to perform the calculations required to simulate the interaction of liquids and gases with surfaces defined by boundary conditions

Course Objectives:

Equip students with the knowledge base essential for application of computational fluid dynamics to engineering flow problems.

2. Provide the essential numerical background for solving the partial differential equations governing the fluid flow.

3. Develop students' skills of using a commercial software package

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Bloom's Cognitive Descriptor
CO1	Build flow problem properly within CFD context.	3	Applying
CO2	Take part in solid modeling and meshing.	4	Analyzing
CO3	Assess the CFD results by comparing with available data, and discuss the findings.	5	Evaluating

CO-PO,PSO Mapping:

CO	PO1	PO2	PO3	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	-	-	-	-	-	-	-	2	-	1
CO2	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	3	-	-	-	-	-	-	2	-	-	-	3	2	-

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:	
UNIT 1: **Introduction to Computational Fluid Dynamics :** Computational Fluid Dynamics: What, When, and Why?, CFD Applications, Numerical vs Analytical vs Experimental, Modeling vs Experimentation. **Principles of Conservation:** Reynolds transport theorem, Conservation of mass, Conservation of linear momentum: Navier-Stokes equation, Conservation of Energy, General scalar transport equation. **Classification of Partial Differential Equations and Physical Behaviour:** Mathematical classification of Partial Differential Equation, Illustrative examples of elliptic, parabolic and hyperbolic equations, Physical examples of elliptic, parabolic and hyperbolic partial differential equations	07 **Hrs.**
UNIT 2: **Approximate Solutions of Differential Equations:** Error Minimization Principles, Functional involving higher order derivatives, Approximate solution of differential equations through variational formulation, Boundary conditions in the variational form: Primary and secondary variables, Essential and natural boundary conditions, Approximate solutions of differential equations, Properties of variational form, Weighted residual approach: trial function and weighting function, Requirement of trial function and weighting function, Least square method, Point Collocation method, Galerkin's method, Rayleigh-Ritz method	07 **Hrs.**
UNIT 3: **Fundamentals of Discretisation:** Pre-processing, Solution, Post-processing, Finite Element Method, Finite difference method, Well posed boundary value problem, Possible types of boundary conditions, Conservativeness, Boundedness, Transportiveness, **Finite Volume Method:** Some Conceptual Basics and Illustrations through 1-D Steady State Diffusion Problems: FV Discretisation of a 1-D steady state diffusion type problem, Implementation of boundary conditions	06 **Hrs.**
UNIT 4: **Discretisation of Unsteady State Problems:** 1-D unsteady state diffusion problems: implicit, fully explicit and Crank-Nicholson scheme**.** Consequences of time-discretisation in finite discretisation, Consistency, Stability, Convergence, Stability analysis of parabolic equations (1-D unsteady state diffusion problems), Stability analysis of parabolic equations (1-D unsteady state diffusion problems), Stability analysis of hyperbolic equations: **Solution of Systems of Linear Algebraic Equations:** Criteria for unique solution, infinite number of solutions and no solution, Solution techniques for systems of linear algebraic equations, Generalized analysis of the iterative methods, Sufficient condition for convergence, Rate of convergence, Relaxation methods, Gradient search methods: Steepest descent method and Conjugate gradient method	08 **Hrs.**
UNIT 5: **Discretisation of Convection-Diffusion Equations:** A Finite Volume Approach: Finite volume discretisation of convection-diffusion problem: Generalized convection-diffusion formulation, **Discretisation of Navier Stokes Equations:** Discretisation of the Momentum Equation: SIMPLE Algorithm, SIMPLER Algorithm **Unstructured Grid Formulation:** Discretisation of the Momentum Equation using unstructured grid	06 **Hrs.**
UNIT 6:	06**Hrs.**

What is there in implementing a CFD code?: The basic structure of a CFD code: Pre-processor, Solver and Post-processor, User-defined-subroutines, Solution to some basic problems in heat transfer and fluid flow. **Introduction to Turbulence Modeling:** Important features of turbulent flow, Vorticity transport equation, Statistical representation of turbulent flows: Homogeneous turbulence and isotropic turbulence, General Properties of turbulent quantities, Reynolds average Navier stokes (RANS) equation, Closure problem in turbulence: Necessity of turbulence modeling, Different types of turbulence model: Eddy viscosity models, Mixing length model, Turbulent kinetic energy and dissipation, The κ-ε model, Advantages and disadvantages of κ-ε model, More two-equation models: RNG κ-ε model and κ-ω model, Reynolds stress model (RSM),Large eddy Simulation (LES),Direct numerical simulation (DNS)	

Textbooks:

1. H. K. Versteeg & W. Malalasekera, An Introduction to Computational Fluid Dynamics, Longman Scientific & Technical.
2. John D. Anderson Jr., Computational Fluid Dynamics, McGraw Hill Book Company.
3. J. Blazek, Computational Fluid Dynamics: Principles and Applications, Elsevier.

References:

1. S. V. Patankar, Numerical Heat Transfer and Fluid Flow, McGraw-Hill.
2. T. J. Chung, Computational Fluid Dynamics, Cambridge University Press.
3. J. H. Ferziger and M. Peric, Computational Methods for Fluid Dynamics, Springer.
4. John C. Tannehill, Dale A. Anderson and Richard H. Pletcher, Computational Fluid Mechanics and Heat Transfer, Taylor & Francis.

Unit wise Measurable students Learning Outcomes:

1. Graduates will be able to formulate equations of computational fluid dynamics.
2. Graduates will be able to solve differential equations of computational fluid dynamics.
3 . Graduates will be able to discretise the computational fluid dynamics problem
4. Graduates will be able to discretise the Unsteady State Problems.
5 .Graduates will be able to discretise Convection-Diffusion Equations and Navier Stokes Equations
6. Graduates will be able to explain the fundamentals of Turbulence Modeling

Title of the Course: Total Quality Management **Course Code: UMEE0624**	**L**	**T**	**P**	**Credit**
	3	**--**		**3**

Course pre-requisite: knowledge of industrial management and Statistics

Course Description: Course describes about the basics of quality management and deals with the basics all aspects of quality**.**

Course Objectives:

To enhance the ability to control, monitor and implement the quality system in the organization

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive level	Descriptor
CO1	Define quality, customer, supplier	I	Remember
CO2	Discuss statistical tools and techniques	II	Understanding
CO3	Explain advance management tools for Quality control	II	Understanding
CO4	Apply Hands on skills in problem solving and controlling and improvement of quality.	III	Applying

CO-PO Mapping:

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

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:	
Unit 1:-- **Basic concepts of Quality and TQM -** Introduction to Quality, Evolution of Quality, Quality Definition, Dimensions of Quality, Introduction to TQM, Basic Concepts of TQM, TQM Framework (Elements of TQM), Principles of TQM, Barriers to TQM Implementation, Introduction to Quality Gurus, W. Edwards Deming, Joseph M. Juran, Philip Crosby, Cost of quality (COQ or Quality Costs)	**6Hrs.**
Unit 2:--- **Customer Satisfaction and Employee involvement-** Understanding Customer Satisfaction, customers, Customer's Perception of Quality, Identifying Customer Needs, Customer Complaints (Customer Feedback); Understanding Employee **involvement,** Motivation, Employee Empowerment, Team and Team Work.	**8 Hrs.**
Unit 3:-- TQM Principles and Leadership**:-** Principles, Characteristics or Behaviours of Quality Leaders, Leadership Styles for Effective Leaders, Requirements of Effective Leadership, Deming's 14 Points for Management, Role of Senior Management (Role of TQM Leaders), Leading Practices for Leadership, Quality Council, Strategic Quality Planning	**6Hrs.**
Unit 4:--- **Supplier Partnership And Quality Circles**- Principles of Customer/Supplier Relations, Supplier Partnering, Supplier Sourcing, Supplier Selection, Supplier Certification, Supplier Rating. Defining Quality Circles, Characteristics of Quality Circles, Structure of Quality Circle, Process of Quality Circle Operation.	**5 Hrs.**
Unit 5:-- **TQM Tools and Techniques-** introduction to Seven Basic Tools of Quality, Flow Chart, Check Sheet (Data Collection Sheet, Histogram, Pareto Diagram, Cause and Effect Diagram (or Fishbone Diagram), Scatter Diagram, Control Chart. Defining Benchmarking, Types of Benchmarking, Benchmarking Process, Benefits of Benchmarking	**7 Hrs.**
Unit 6:-- **Advanced concepts-** **Introduction to FMEA, Six-Sigma, QFD, TPM, Kaizen, 5S, Introduction to ISO-9001:2015** Quality Management System	**8Hrs.**
Textbooks: 1. Dale H. Besterfiled, "Total Quality Management", Pearson Education Asia 2. Jain K. C, "Total Quality Management and Business Process Transformation", Khanna Publishers, 2009 Edition	

3. Dr. V. Jayakumar, Dr. R.Raju, "Total Quality Management", Lakshmi Publications-Chennai.
4. Rose, J.E. Total Quality Management, Kogan Page Ltd. 1993.
5. John Bank, The essence of total quality management, Prentice Hall, 1993.

References:

1. J M Juran, FM Gryana, *"Quality planning and analysis",* Tata McGraw Hill
2. D. H. BesterField et al., "*Total Quality Management"*, Prentice Hall.
3. Philip B Crossbly, "*Quality is free"*, Mentor/ new American library.
4. Ishikawa K., "*What is Total Quality Control? The Japanese way"*, Prentice Hall.
5. Armand V Feigenbaum, "*Total Quality Control*", McGraw Hill
.

Unit wise Measurable students Learning Outcomes:

1) To define quality and explain the evolution of quality
2) To select and explain customer involvement,
3) To select and explain Leadership styles for Quality management,
4) To select and explain supplier involvement
5) To select and explain tools and techniques for problem solving
6) To explore advanced concepts in TQM.

Title of Course : Entrepreneurship Development **L-3 T- 0 P- 0**

Course Code : UMEE0625

Course Pre- Requisite : Genuine interest in development of entrepreneurial mindset. Planning competency and global awareness competency

Course Description : Familiarize students with fundamentals of entrepreneurship, study government support organizations for entrepreneurs, study the process of starting the industry besides studying the ecosystem available for new entrepreneurs

Course Objectives :

1. To develop conceptual understanding of the topic among the students and comprehend the environment of making of an Entrepreneur
2. To develop the ability of analyzing and understanding business situations in which entrepreneurs act and to master the knowledge necessary to plan entrepreneurial activities

Course learning outcomes :

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		Level	Descriptor
CO1	Relate the concept of Entrepreneurship and describe the role of entrepreneurship within society	I	Remember
CO2	Discuss Market research, Survey, Project report, business finance	II	Understand
CO3	Describe marketing, sales, operations and accounting activities.	II	Understand
CO4	Use/ Demonstrate/ Interpret /Apply entrepreneur inputs for starting and establishing business	III	Apply

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10		
CO1												
CO2												
CO3												
CO4												

Assessment :

ISE -I	**10**	**20**	**40**
MSE	**30**		
ISE-II	**10**		
ESE	**50**	**20**	

ISE 1 and ISE 2 are based on presentation of Innovative Idea/ Business case presentation through PPT/Prototype Model /declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with60-70% weight age for course content (normally last three modules) covered after MSE.

Course Content:

Unit One

Entrepreneur and Market Research **(6 Hours)**

Introduction to Entrepreneurship, Profile of the Entrepreneur, Entrepreneurial Competencies, Role of Entrepreneurship in Economic Development, Market Gap / Opportunity Analysis, Market Research Methods, Defining the Focal Market: Market Segmentation, Industry analyzing – Research / Competitive Analysis

Urban and Rural Entrepreneurship: Concept, Need, Problems, Rural Industrialization in Retrospect, How to Develop Rural Entrepreneurship, NGOs

Women Entrepreneurship - Concept, functions, Growth of Women Entrepreneurs, Problems, Development of Women Entrepreneurs

Small Enterprises: Definition, Characteristics, Relationship between Small and Large Units, Role of small Enterprise in Economic development

Unit Two

Project Identification, Selection and Management **(6 Hours)**

Meaning of Project, Project Identification, Project Selection, Project Formulation: Meaning, Significance, Contents, Formulation, Planning Commission's Guidelines for Formulating a Project Report, Specimen of a Project Report, Network Analysis, Common Errors in Project Formulation, Project Appraisal Concept, ,Methods of project appraisal.

Unit three

Business Finance : **(6 Hours)**

Need for Financial Planning, Sources of finance, Capital Structure, Term-loan, Sources of Short-Term Finance, Capitalization, Venture capital, Export Finance, Institutional Finance To Entrepreneurs, Institution Support To Entrepreneurs, Business lifecycle, Break even.

Unit Four

Marketing , Sales **(6 Hours)**

Marketing - Basics, Marketing Strategy and Brand Positioning, Plans and Execution Techniques, Marketing Analytics, Online Marketing

Sales -Understanding Sales, Pitching Techniques, Sales strategies, Inside Sales v/s Outside Sales, Request for Proposal(RFP)

Unit Five

Operation Management (6 Hours)

Techniques of materials, production, manpower resources management, Process Analysis, Productivity, Quality . Crisis management, study process, reasons of failure

Unit Six

Costing and Accounting (6 Hours)

Direct and Indirect costs, Financial appraisal, Financial projection, Income tax, Profit and loss account , Balance sheet, , Goods and Service tax, letter of credit, over draft , Excise Tax and Export process.

Text Books:

1. Roy Rajeev, Entrepreneurship Oxford Latest Edition
2. E. Gordon & K. Natarajan Entrepreneurship Development Himalaya 2008
3. Coulter Entrepreneurship in Action PHI 2nd Edition
4. Ram Chandran, „Entrepreneurial Development", Tata McGraw Hill, New Delhi
5. Saini, J. S., „Entrepreneurial Development Programmes and Practices" , Deep & Deep Publications (P)
6. Poornima M Charantimath, "Entrepreneurship development small business enterprises", Pearson,2013
7. Developing New Entrepreneurs - Entrepreneurship Development Institute of India,Ahmedabad
8. Handbook of New Entrepreneurs
9. Management of Small Scale Industry - Vasant Desai (Himalaya Publication)
10. Entrepreneurship Playing to Win- Gordon Betty (Taraporwala & Co.)
11. Motivating Economic Achievement- David C. McClelland, David G. Winter
12. Industrial Maharashtra- Facts, Figures and Opportunities (M.I.D.C. Mumbai)
13. Project Planning & Entrepreneurship Development - T. R. Banga
14. Dynamics of Entrepreneurial Development & Management- Vasant Desai
15. S.S.I. and Entrepreneurship- Vasant Desai (Himalaya Publication)
16. Petersen and Lewis : Managerial Economics, 4/e, Pearson/PHI, 2002
17. Managerial Economics, Ahuja. H.L, S. Chand, New Delhi.
18. M.L. Trivedi: Managerial Economics, Tata Mc-Graw Hill, New Delhi 2004.
19. Ramachandran, and Kakani, —How to Analyze Financial Statements, Tata McGraw Hill
20. Palat, Raghu, —How to Read Annual Reports and Balance Sheets‖, JAICO Publishing House
21. Dash A.P., —Financial Wisdom – Finance for Non-Finance Executives‖, Biztantra ISBN 978-81-7722-378-1
22. Martin M.J., Managing Innovation and Entrepreneurship in Technology based Firm, John Wiley, 1994
23. Ettlie J.E., Managing Technology Innovation, John Wiley & Sons, 2000

24. Christensen C. M. and Raynor, M. E., The Innovator's Solution: Creating and Sustaining Successful Growth, Boston, MA: Harvard Business School Press, 2003
25. The Startup Playbook: Secrets of the Fastest-Growing Startups From Their Founding Entrepreneurs by David Kidder
26. Creativity, Inc.: Overcoming the Unseen Forces That Stand in the Way of True Inspiration by Ed Catmull
27. Bhargava, S. (2003). Transformational leadership: Value based management for Indian Organizations (Ed.). New Delhi: Response-Sage.
28. Cardullo, M. W. P. E. (1999). Technological entrepreneurism: Enterprise formation,financing, and growyh. England: Research Studies press Ltd.
29. Hisrich, R. D. & Peters, M. P. (2001). Entrepreneurship: Starting, developing, and managing a new enterprise (5th Ed.). New York: McGraw-Hill

Reference Book:

1. P. C. Jain Handbook For New Entrepreneur Oxford Latest Edition
2. S. S. Khanka Entrepreneurial Development S. Chand Latest Edition
3. Thomas W. Zimmerer& Norman M. Scarborough
4. Essentials of Entrepreneurship and small business management PHI 4th Edition
5. Dr. Vidya Hattangadi Entrepreneurship Himalaya 2007
6. Vasant Desai Small Scale Industries and Entrepreneurship
7. Badhai, B „Entrepreneurship for Engineers", Dhanpat Rai & co. (p) Ltd.
8. Gupta and Srinivasan, „Entrepreneurial Development", S Chand & Sons, New Delhi
9. Drucker.F, Peter, "Innovation and Entrepreneurship, Harper business, 2006
10. Motivating Economic Achievement- David C. McClelland, David G. Winter
11. Harvard Business Review on Innovation (Collection of articles), Harvard Business School Press, 2001
12. Harvard Business Review on Entrepreneurship (Collection of articles), Harvard Business School Press, 1999
13. Rogers, E.M., Diffusion of Innovations, Fifth Edition, New York: Simon and Schuster, 2003
14. Kanungo, R. N. (1998). Entrepreneurship and innovation: Models for development (Ed., Vol.2). New Delhi: Sage.
15. Van Nostrand. Verma, J. C., & Singh, G. (2002). Small business and industry: A handbook for entrepreneurs. New Delhi: Response-Sage.
16. Richard A Brealy & Steward C Myres. Principles of Corporate Finance, McGraw Hills, 7thEdn,2004
17. Prasanna Chandra, Financial Management: Theory and Practice, Tata McGraw Hills, 6th Edn, 2004
20. I.M. Pandey & Ramesh Bhat, "Cases in Financial Management", Tata McGraw-Hill, New Delhi

Suggested Software / Learning websites

MCED Books links	http://www.mced.nic.in/UdyojakSpecial.aspx?linktype=Udyojak
MCED Product and Plan Details	http://www.mced.nic.in/allproduct.aspx
The National Institute for Entrepreneurship and Small Business Development Publications	http://niesbud.nic.in/Publication.html
Courses : The National Institute for Entrepreneurship and Small Business Development	http://niesbud.nic.in/docs/1standardized.pdf
Entrepreneur.com	https://www.entrepreneur.com/lists
GOVT. SPONSORED SCHEMES	https://www.nabard.org/content1.aspx?id=23andcatid=23andmid=530
NABARD - Information Centre	https://www.nabard.org/Tenders.aspx?cid=501andid=24
NABARD – What we Do	http://www.nabard.org/content1.aspx?id=8andcatid=8andmid=488
Market Review	http://www.businesstoday.in/markets
Start Up India	http://www.startupindia.gov.in/pdffile.php?tit=Startup%20India%20Action%20Planandtyp=Actionandq=Action%20Plan.pdfandcontent_ype=Actionandsubmenupoint=action
About - Entrepreneurship Development Institute of India (EDII)	http://www.ediindia.org/institute.html
EDII - Centres	http://www.ediindia.org/centres.html
EDII - Publications	http://www.ediindia.org/publication.html
Business Plans: A Step-by-Step Guide	https://www.entrepreneur.com/article/247574
The National Science and Technology Entrepreneurship Development Board	http://www.nstedb.com/index.htm
NSTEDB - Training	http://www.nstedb.com/training/training.htm
Tata Exposures	http://www.tatasocial-in.com/project-exposure
Ministry Of Micro, Small And Medium EnterpriseS	http://www.dcmsme.gov.in/schemes/TEQUPDetail.htm
List of Business Ideas for Small Scale Industry	https://smallb.sidbi.in/%20/thinking-starting-business/big-list-business-ideas-small-business
Thinking of Entrepreneurship	https://smallb.sidbi.in/entrepreneurship-stage/thinking-entrepreneurship
List of services for Small Scale Industry	http://www.archive.india.gov.in/business/Industry_services/illustrative.php
NSIC Schemes and Services	http://www.nsic.co.in/SCHSERV.ASP

Unit wise Measurable Students Learning Outcomes

1. Students would understand different types of Entrepreneurial ventures and would be able to discover, develop, and assess opportunities

2. Students would understand and develop industrial Project Reports
3. Students will identify role of Institutional finance and support for business
4. Students will understand marketing and sales strategies
5. Students will get to know how organization operates
6. Students will learn concepts of business finance

Title of the Course:
Computer Integrated Manufacturing
Course Code: UMEE0626

L	T	P	Credit
3	-	-	3

Course Pre-Requisite:
Knowledge of basic manufacturing processes

Course Description:
It is the study of manufacturing planning, integration and implementation of automation. It contains Computer Aided Manufacturing (CAM), studies of Concurrent Engineering, Group Technology, Computer Aided Process Planning and Flexible Manufacturing Systems and Networking concepts.

Course Learning Objectives:

1. To understand the basic concepts of computer aided manufacturing, design and engineering and concept of group technology
2. To understand the subsystems in CIMS, such as computer aided process planning, flexible manufacturing, production management, quality control and material handling, and their integration
3. To understand the role of database management and communication systems in integration
4. To understand different data acquisition techniques.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		Level	Descriptor
CO1	Explain the link between Automation and CIM	II	Understanding
CO2	Make use of computer in Manufacturing and design process	III	Applying
CO3	Develop part family classification code using the concept of group technology.	III	Applying
CO4	Apply knowledge of computer aided process planning and flexible manufacturing in manufacturing processes.	III	Applying
CO5	Apply artificial intelligence in manufacturing.	II	Applying
CO6	Select appropriate networking topology for given application	V	Evaluating

CO-PO Mapping:

CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2
CO1	2													1
CO2		1			3								2	
CO3		1	3											
CO4		1	2										2	
CO5		1												1
CO6				1	2								1	

Assessments :

Teacher Assessment:
Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:- Basic Concept of CIMS:- **6 Hrs.**

Scope, islands of automation, architecture of CIM, information flow in CIM, elements of CIM, benefits, limitations, obstacles in implementation Planning for CIMS, need for planning, Phases of CIM implementation, incremental implementation and one time implementation, CIM benchmarking, Economic and social justification of CIM.

Unit 2:- **6 Hrs.**

Product Design and CAD, application of computers in design, CAM – manufacturing planning and control, scope of CAD / CAM and CIM, Concurrent engineering, Design for manufacturing and assembly ,Case studies on Concurrent engineering, Design for manufacturing and assembly.

Unit 3: **8 Hrs.**

a) Group Technology: Concept, design and manufacturing attributes, part families, composite part, methods of grouping, PFA, classification and coding system- OPITZ, Relevance of GT in CIM, GT and CAD, benefits and limitations of GT.

b) Computer Aided Process Planning and Control: need, retrieval and generative type CAPP, role of CAPP in CIM.

c) Computer Aided Production Planning and Control: Computer integrated production management system, Role of computers in aggregate planning, master production schedule, shop floor control, materials requirement planning, and capacity planning, manufacturing resource planning and enterprise resource planning

Unit 4: Flexible Manufacturing Systems, Transfer lines, Assembly Lines in CIMS: **6 Hrs.**

Concept, flexible & rigid manufacturing, manufacturing cell and FMS structure, types, components of FMS, Distributed Numerical Control (DNC), Building Blocks of FMS, Flexible Assembly System, Transfer Lines, concept, applications, benefits, Automates assembly lines, Design for assembly.

Unit 5: Applications of Artificial Intelligence amd Machine Learning in Manufacturing **6 Hrs.**

Concept of smart machines, SmartCorrect, Autonomous decision making
Introduction to smart material handling devices and storage system

Unit 6: **8 Hrs.**

a) Data Acquisition and Database Management Systems: (a) Data acquisition system, type of data, automatic data identification methods, bar code technology, machine vision.(b) Data and database management system, database design requirements, types of DBMS models- hierarchical, network and relational models and their applications

b) Communication in CIMS: Role of communication in CIMS, requirements of shop floor communication, types and components of communication systems in CIM, Networking concepts, network topology, access methods, ISO-OSI reference model for protocols, MAP/TOP, TCP/IP.

Reference :

1) Performance Modeling of Automated Manufacturing Systems, 2/e - Viswanadham, N & Narahari,

Y. (EEE) (PHI)
2) CIM Handbook - Teicholtz& Orr (McGraw Hill) Computer Integrated Manufacturing, 2/e - James A. Rehg, H. W. Kraebber, (Pearson Education)

Textbooks:

1) Automation, Production systems and Computer Integrated Manufacturing, 3/e - M.P. Groover (PHI or Pearson Education)
2) Computer Integrated Design and Manufacturing - Bedworth, Henderson & Wolfe,(McGraw Hill)
3) Principles of Computer Integrated Manufacturing - S. Kant Vajpayee, (PHI)
4) CAD / CAM Principles and Applications - P.N. Rao (Tata McGraw Hill)
5) CAD/CAM/CIM, 3/e – Radhakrishnan, Subramanayam & Raju (New Age International)
6) MAP/TOP Networking : Foundation of CIM – Vincent Jones (McGraw Hill)

Unitwise Measurable outcomes:

1. The student shall be able to understand basic concepts of CIMS
2. The student shall be able to learn the applications of CAD and CAM
3. The student shall be able to understand importance of GT and CAPP
4. The student shall be able to understand the concept of FMS
5. The student shall be able to understand role of artificial intelligence in manufacturing.
6. The student shall be able to understand the concept of DBMS

Title of the Course: Product Lifecycle Management **L T P C**

Course Code: UMEO0601 **3 - - 3**

Course Pre-Requisite: Manufacturing Engineering ,Operations Management, Industrial Product Design

Course Description:

The **Product Lifecycle Management** theory includes the detail study Product Lifecycle Management. , driving environment, digital life cycle, different components of plm.

Course Objectives:

1. Student will able to understand fundamentals of Product Lifecycle Management.
2. Student will able to understand life cycle management & driving environment of plm
3. Student will able to understand digital life cycle and environment of plm
4. Student will able to understand different components of plm.

Course Learning Outcomes:

CO	**After the completion of the course**	**Bloom's Cognitive**	
		level	**Descriptor**
CO1	Student will able to understand fundamentals of Product Lifecycle Management.		
CO2	Student will able to understand life cycle management & driving environment of plm		
CO3	Student will able to understand digital life cycle and environment of plm		
CO4	Student will able to understand different components of plm.		

CO-PO Mapping:

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

Strength of Correlation: Key: 3: High, 2:Medium, 1:Low

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) andone End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with 60-70% weightage for course content(normally last three modules) covered after MSE.

Course Contents:

Unit 1: - INTRODUCTION TO PRODUCT LIFE CYCLE MANAGEMENT: **6Hrs.**
Product life cycle – Introduction, growth, maturity & decline, Product Lifecycle Management- Definition & Overview, challenges, Need of PLM, Components/Elements of PLM, Emergence of PLM, Significance of PLM - life cycle problems to be resolved, product development problems to be resolved, Customer Involvement

Unit 2: - CONSTRUCTING PRODUCT LIFE CYCLE MANAGEMENT & DRIVING ENVIRONMENT - PLM Life cycle model- plan, design, build, support & dispose. Threads of PLMcomputer aided design (CAD), engineering data management (EDM), Product data management (PDM), computer integrated manufacturing (CIM). Weaving the threads into PLM, comparison of PLM to Engineering resource planning (ERP). PLM characteristics - singularity, cohesion, traceability, reflectiveness, Information Mirroring Model. External drivers- scale, complexity, cycle times, globalization & regulation. Internal drivers - productivity, innovation, collaboration & quality. , **8 Hrs.**

Unit 3: - DIGITAL LIFE CYCLE - Collaborative Product Development, Mapping Requirements to specifications. Part Numbering, Engineering Vaulting, Product reuse, Engineering Change Management, Bill of Material and Process Consistency. Digital Mock up and Prototype development. Virtual testing and collateral. Introduction to Digital Manufacturing. **6 Hrs.**

Unit 4: PRODUCT LIFE CYCLE MANAGEMENT SYSTEM: Product life cycle management system- system architecture, Information models and product structure, Information model, the product information data model, the product model, functioning of the system. Reasons for the deployment of PLM systems **06 Hrs.**

Unit 5: - PRODUCT LIFE CYCLE ENVIRONMENT: Product Data issues – Access, applications, Archiving, Availability, Change, Confidentiality. Product Workflow, The Link between Product Data and Product Workflow, Key Management Issues around Product Data and Product Workflow, Company's PLM vision, The PLM Strategy, Principles for PLM strategy, Preparing for the PLM strategy, Developing a PLM strategy, Strategy identification and selection, Change Management for PLM. **06 Hrs.**

Unit 6: COMPONENTS OF PRODUCT LIFE CYCLE MANAGEMENT: Different phases of product lifecycle and corresponding technologies, Foundation technologies and standards e.g. visualization, Core functions e.g., data vaults, document and content management, workflow and program management, Functional applications e.g., configuration management. Human resources in product lifecycle. **08 Hrs.**

Text Books:

1. Grieves Michael, Product Lifecycle Management- Driving the Next Generation of LeanThinking, McGraw-Hill, 2006. ISBN 0071452303
2. Antti Saaksvuori, Anselmi Immonen, Product Life Cycle Management - Springer, 1stEdition (Nov.5, 2003)
3. Stark, John. Product Lifecycle Management: 21st Century Paradigm for Product Realization, Springer-Verlag, 2004. ISBN 1852338105.
4. AnttiSaaksvuori and AnselmiImmonen, "Product Lifecycle Management", SpringerPublisher, 2008.
5. Michael Grieves, "Product Life Cycle Management", Tata McGraw Hill, 2006.

References:

1. ArieKarniel and Yoram Reich, Managing the Dynamics of New Product Development Processes: A New Product Lifecycle Management Paradigm, Springer, 2011.
2. IvicaCrnkovic, Ulf Asklund and AnnitaPerssonDahlqvist, "Implementing and Integrating Product Data Management and Software Configuration Management", Artech House Publishers, 2003.
3. John Stark, "Global Product: Strategy, Product Lifecycle Management and the Billion Customer Question", Springer Publisher, 2007.
4. John Stark, "Product Lifecycle Management: 21st Century Paradigm for Product Realisation", Springer Publisher, 2011.
5. Kevin Roebuck, Product Lifecycle Management (PLM): High-impact Strategies – What You Need to Know: Definitions, Adoptions, Impact, Benefits, Maturity, Vendors, Emereo, 2011.

Title of the Course: Advance Energy Technology Course Code:UMEO0602	L	T	P	Credit
	03	-		3

Course Pre-Requisite: Basic Physics, Chemistry, Basic Mechanical Engg

Course Description: Basic Physics, Engineering Thermodynamics, Fluid and Turbomachinery. I.C. Engines.

Course Objectives:

1. Acquire the knowledge of renewable sources of energy and utilization.
2. Enable the student to estimate the potential of energy sources.
3. Study various power stations , Performance and economic analysis
4. Understand the new trends in power and energy sectors

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Demonstrate need of different energy sources and their importance	II	Understanding
CO2	Illustrate power plant economics	II	Understanding
CO3	Analyze the utilization of solar, wind energy etc	IV	Applying

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3												2		
CO2	3												2		
CO3		3										2			
CO4				2									2		

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:---	**6 Hrs.**
Introduction to Renewable Energy sources-Environmental degradation due to energy production and utilization, primary and secondary pollution-air, thermal and water,	

depletion of ozone layer, global warming, biological damage due to environmental degradation, pollution due to thermal power stations and their control, Energy management and marketing, Energy audit .	
Unit 2:--- Introduction to Solar Energy , Solar potential, Solar radiation spectrum, Solar radiation geometry (Numerical on angle of incidence only), Solar radiation data, ,Solar Collectors (Flat plate, evacuated tube, Cylindrical parabolic, Concentrating paraboloid),Graphical representation of efficiency of various Collectors , Testing of Solar flat plate collectors – BIS code (No numerical), Thermal Energy storage (Introduction and types)	**7 Hrs.**
Unit 3:--- Operating Principle of Photovoltaic cell concepts, Photo-cell materials, Cell module array, Series and parallel connections, Maximum power point tracking, Design of standalone system with battery and AC or DC load (Descriptive Treatment), Applications, Introduction, Principle and operation of fuel cells, classification and types of fuel cell. Fuel for fuel cells, Application of fuel cells.	**7 Hrs.**
Unit 4:--- Wind parameters and wind data, Power from wind, Site selection, Wind energy conversion systems and their classification, Construction and working of typical wind mill, Introduction to OTEC and Hybrid systems (Diesel-PV, Wind-PV Biomass-Diesel systems)	**6Hrs.**
Unit 5:--- Other Renewable Energy Sources Biomass: as a source of energy, Classification of biomass, Biomass conversion processes, Biogas plant and its components, Types of biogas plants. Geothermal Energy: Resources, types of wells, methods of harnessing the energy, potential in India. Ocean Energy: Ocean Thermal Energy Conversion, Principles utilization, setting of Ocean Thermal Energy Conversion plants, Comparison with normal thermal power cycles. Tidal and wave energy: Potential and conversion techniques, mini-hydel power plants, and their economics	**8 Hrs.**
Unit 6:--- Energy efficiency and energy conservation in boilers, furnaces, HVAC, motors, compressors, etc. solar passive architectural techniques and Green buildings, Energy Conservation and its Importance; Energy Strategy for the Future; The Energy Conservation Act, 2001 and its Feature, Energy Management .	**6 Hrs.**
Text Books – 1. Non-conventional energy sources by G.D. Rai, Khanna Publishers 2. Solar Energy: Principles of Thermal Collection and Storage by S,P Sukhatme, Tata McGraw Hill 3. Solar Engineering of Thermal processes, J.A.Duffie and W.A.Beckman, 2ndedition, John Wiley, New York, 1991. 4. Handbook of Biogas Technology, Prattek Shilpkar & Deepti Shilpkar	
References: 1. Fuel Cells by Bockris and Srinivasan; McGraw Hill. 2. Solar Energy: Fundamentals and Applications by H.P. Garg& Jai Prakash, Tata McGraw Hill. 3. Wind Power Technology, Joshua Earnest, PHI Learning, 2014 4. Non Conventional Energy Resources by S. Hasan Saeed and D. K. Sharma, S. K. Kataria&	

Sons.
5. Renewable Energy Sources, J W Twidell& Anthony D. Weir. ELBS Pub.
6. Energy Conversion Systems, R D Begamudre, New Age International (P) Ltd., Publishers, New Delhi ,2000.
7. Principles of Solar Engineering, D.Y.Goswami, F.Kreith and J.F.Kreider, Taylor and Francis,Philadelphia, 2000..

Unit wise Measurable students Learning Outcomes:

After completion of unit , students are able to

1. Explain importance of renewable energy
2. Explain fundamental knowledge of Solar Energy
3. Explain working principle of photovoltaic cell
4. Explain fundamental knowledge of Wind Energy
5. Explain fundamental knowledge of Biomass, Wave,Tidal, Ocean, Energy
6. Explain fundamental knowledge of Energy conservation and management

Title of the Course: Project Management		L	T	P	Credit
Course Code: UMEO0603		3	-	-	3

Course Pre-Requisite: Basic concepts of management

Course Description:

Course comprises of introduction to functions of management, project management, project identification selection and project planning. It covers concepts of project activities, work breakdown structure, activity duration, resource requirements. It also introduce about project scheduling, project risk management, projec costing ,project execution, control and close-out.

Course Objectives:

1. To define concepts of management, project and project management, project identification and planning
2. To explain various steps in work breakdown structure, resource requirements.
3. To identify elements of project schedules, durations, project risks involved.
4. To analyse various aspects of project costing, project execution, control and close-out

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Define concepts related to management, project and project management, project identification and project planning	I	Remembering
CO2	Explain basics of work breakdown structure, resource requirements.	II	Understanding
CO3	Identify elements of project schedules, project durations, risks involved in project management, computers in project management	III	Applying
CO4	Analyse aspects of project costing, project execution, control and close-out	IV	Analyzing

CO-PO-PSO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1				2					2		3			1	1
CO2				2					2	1	3			1	1
CO3				2					2	1	3			1	1
CO4				2					2	1	3			1	1

Course Contents:

Unit 1: Introduction to Project Management Basic functions of management, Difference between general management & project management, Definition of a project, project management & its need, characteristics, objectives & importance of projects, classification of projects, project management process ,project management life cycle & its phases, roles and responsibilities of project managers, types of project managers	07 Hrs.
Unit 2: Project Identification, Selection, Planning Project ideas and sources, steps in project identification process, feasibility studies and types, feasibility report and its contents, financial institutions, project break even point project planning-scope, delivery, resources, budget, quality & risk, forms of organization structures-functional. geographical, product, matrix, pure	07 Hrs.

Unit 3: Project Activities, Work Breakdown structure, Activity duration, Resource Requirements Work breakdown structure (wbs)-product oriented and functionally oriented wbs, responsibility chart and responsibility matrix, integrating wbs and organization structure methods for estimating activity duration, determining resource requirements	06Hrs.
Unit 4: Project Scheduling Activity, events, work packages, Gantt chart, network scheduling analysis PERT &CPM: Introduction to project evaluation and review, introduction to critical path method, deciding project duration using network diagram, finding critical path, calculation of earliest start time, latest finish time, slack, total float, free float, three time estimates, variance	08Hrs.
Unit 5: Project Risk Management Introduction, risk, risk management, steps in risk management, Risk Analysis, computers in project management	04 Hrs.
Unit 6: Project Costing ,Project Execution, Control, Close-out Elements of cost estimates and budgets of projects, Project execution & Control-conduct project execution and control kick-off, manage cssq (cost, scope, schedule, quality) monitor & control risk. manage project execution ,gain project acceptance, Project close-out, steps for closing the project	08 Hrs.

Textbooks:

1.Engineering Project Management-Parameshwar P Iyer-Vikas Publishing House Pvt Ltd
2.Project Management- S. Choudhury, - TMH Publishing Co. Ltd, New Delhi
3.Prasanna Chandra, ―Projects – Planning, Analysis, Financing, Implementation and Review, Tata McGraw Hill,4th Ed, 1997

References:

1. NYS Project Management Guidebook -Release 2
2.John M Nicholas, ―Project Management for business and technology, 2nd edition, Pearson Education Asia, 2001
3.Effective Project Management Robert K. Wysocki, Robert Beck. Jr., and David B. Crane; - John Wiley & Sons.
4. Total Project Management- The Indian Context- P. K. Joy, - Macmillan India Ltd., Delhi
5. Project Management in Manufacturing and High Technology Operations- Adedeji Bodunde Badiru, -John Wiley and Sons.
6. Fundamentals of PERT/ CPM and Project Management- S.K. Bhattacharjee; - Khanna Publishers, New Delhi

Unit wise Measurable students Learning Outcomes:

1. Student should be able to define concept related to management, project and project management
2. Student should be able to explain process involved in identifying project along with selection and project planning
3. Student should be able to explain concepts like work breakdown structure, activity duration, resource requirements
4. Student should be able to identify various elements of project schedules and durations.
5. Student should be able to identify different kind of risks involved in project management and role of computers
6. Student should be able to analyse aspects of project execution,control and close out.

Title of the Course: Smart Materials Course Code: UMEO0604	L	T	P	Credit
	3	0	0	**3**

Course Pre-Requisite: Chemistry, Physics.

Course Description:

The content of this course covers basics of different smart materials, their potential use in engineering fields. This course is also useful in helping students to learn the use of smart materials to automate the different tasks at micro/nano level workspace and to develop micro/nano system. It will also impart knowledge of nanomaterials, its synthesis and nanocomposites with tailored properties which can be used for several applications.

Course Objectives:

1. To study the working principles of various smart materials.
2. To identify applicability of various smart materials as actuator and sensor.
3. To study advances in smart materials.

Course Outcomes:

CO	On completion of the course, the student will have the ability to:	Bloom's Level
CO1	Classify and select different types of smart materials	1,2
CO2	Comprehend Important Concepts and principles of Smart Materials	2
CO3	Synthesis, sensing and actuation of Piezoelectric Materials, Magneto strictive Materials, Shape Memory Alloys, Electroactive Polymers	5,6
CO4	Synthesis, sensing and actuation of Ferrofluids and Magneto rheological Fluids, Soft Matter, Carbon Nanotubes and Carbon nanostructures, Thermoelectric Materials	5,6
CO5	Classify and select Smart Materials for Energy Applications: Materials used for energy storage	3,4
CO6	Classify and select Composite Materials, Nano Composite Materials	3,4

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	-	-	-	1	-	1	-	-	-	-	-	1	-	-
CO2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	2	-	-	-	-	-	-	-	-	-	-	2	-
CO4	-	-	2	2	-	-	-	-	-	-	-	-	-	2	-
CO4	-	-	3	2	-	-	-	-	-	-	-	-	-	-	-

Assessment Scheme:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weightage respectively.

Assessment Component	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and **ISE 2** are based on Assignment/Declared test/Quiz/Seminar/Group discussions/presentation, etc.
MSE is based on 50% of course content (first three units).
ESE is based on 100% course content with 60-70% weightage for course content (last three units) covered after MSE.

Course Contents		
Unit No.	**Unit Title and Contents**	**Hours**
1	**Introduction to Smart Materials:** Overview of the different types of Smart Materials, Smart materials used in structures, smart material for sensors, actuators controls, memory and energy storage and their inter- relationships, concept of High bandwidth- low strain generating materials (HBLS), and Low Bandwidth High Strain Generating Materials (LBHS), Nano Composites, Characterization.	7
2	**Important Concepts of Smart Materials:** Artificial skins, artificial muscles, biomimetic materials, materials with tuneable responses, non- linear properties, self-healing materials, adaptive structures, self-replicating materials/structures, self-assembly, inch worm devices, hysteresis, integrated sensing and actuation.	8
3	**Overview of the following materials with focus on synthesis, constitutive/governing relationships, strengths and weaknesses, and applications (both sensing and actuation etc).** 1. Piezoelectric Materials 2. Magneto strictive Materials 3. Shape Memory Alloys 4. Electroactive Polymers	6
4	**Overview of the following materials with focus on synthesis, strengths and weaknesses, and applications** 1. Ferrofluids and Magneto rheological Fluids and applications in dampers 2. Soft Matter and its applications as smart skins, smart textiles etc 3. Carbon Nanotubes and Carbon nanostructures and its applications 4. Thermoelectric Materials and Peltier devices.	6
5	**Smart Materials for Energy Applications:** Materials used for energy storage, Hydrogen Storage Materials, Energy harvesting, Energy scavenging from vibrations.	6
6	**Manufacturing techniques for smart materials:** micromanufacturing, high resolution lithography, LIGA process, Generative manufacturing processes such as STL, SLS, SPB, BPM, LOM, SGC, FDM, BIS, BPM, Self-assembly process, Ion beam processes,	7

Textbooks:

1. Inderjit Chopra and Jayant Sirohi, *Smart Structures Theory, Cambridge Press.*
2. V.K. Varadan, K.J. Vinay, and S. Gopalakrishnan, *Smart Materials Systems and MEMS Design and Development Methodologies, John Wiley and Sons.*
3. G. K. Narula, K. S. Narula, V. K. Gupta, "Material Science", TMH, 2007
4. Pradeep T, "Nano: The Essentials", McGraw Hill Publishing Co. Ltd., 2007
5. William D. Callister, Jr. "Materials Science and Engineering An Introduction", John Wiley& Sons, Inc.7th Edition
6. G. Gautschi, "Piezoelectric Sensorics: Force, Strain, Pressure, Acceleration and Acoustic Emission Sensors, Materials and Amplifiers", Springer, Berlin; New York, 2002 (ISBN:3540422595)
7. K. Uchino, "Piezoelectric Actuators and Ultrasonic Motors", Kluwer Academic Publishers, Boston, 1997 (ISBN: 0792398114)
8. A.V. Srinivasan, "Smart Structures: Analysis and Design", Cambridge University Press,Cambridge; New York, 2001 (ISBN: 0521650267)
9. G. Engdahl, "Handbook of Giant Magneto strictive Materials", Academic Press, San Diego, Calif.; London, 2000 (ISBN: 012238640X)
10. K. Otsuka and C.M. Wayman, "Shape Memory Materials", Cambridge University Press, Cambridge; New York, 1998 (ISBN: 052144487X)
11. Eric Udd, "Fibre Optic Sensors: An Introduction for Engineers and Scientists", John Wiley & Sons, New York, 1991 (ISBN: 0471830070)
12. André Preumont, "Vibration Control of Active Structures: An Introduction", 2nd Edition, Kluwer Academic Publishers, Dordrecht; Boston, 2002 (ISBN: 1402004966)
13. HojjatAdeli, "Control, Optimization, and Smart Structures: High-Performance Bridges and Buildings of the Future", John Wiley, New York, 1999 (ISBN: 047135094X)
14. T.T. Soong, "Passive Energy Dissipation Systems in Structural Engineering", Wiley, Chichester; New York, 1997 (ISBN: 0471968218)
15. "Shape memory materials",Edited By- K. Otsuka and C M Wayman, Cambridge Univ.Press
16. "Shape memory polymers and multifunctional composites" Edited by JinsongLeng andShanyi Du,CRC Press.
17. Anke Krueger, "Carbon materials and nano technology", Wiley – VCH
18. M.V. Gandhi and B.S. Thompson, "Smart Materials and Structures", Chapman & Hall, London; New York, 1992 (ISBN: 0412370107
19. Mel Scwartz, "Encyclopedia of Smart Materials Vol. I and II", John Wiley & Sons
20. SenolUtku, "Theory of Adaptive Structures : Incorporating Intelligence into Engineered Products", CRC Press (1998), ISBN: 9780849374319.

Reference Books:

1. Ralph C. Smith, *Smart Material Systems: Model Development, Frontier in Applied Mathematics.*
2. Callister's Materials Science and Engineering.
3. Materials Science And Engineering: An Introduction, William D. Callister Jr., David G. Rethwisch.
4. Handbook of Polymer and Ceramic Nanotechnology, Springer.
5. Nanomaterials: Synthesis, Characterization, and Applications, Sabu Thomas.
6. Nanomaterials synthesis and applications 1st Edition- May 29, 2019.

Additional Resources:

NPTEL, MIT Video Lectures, Web Resources etc.

Title of the Course: Introduction to Robotics **Course Code:** UMEO0605	**L**	**T**	**P**	**Credit**
	3		**--**	**3**

Course Pre-Requisite: Basics of Electrical and Electronics

Course Description: This course introduces the stream of robotics. The course is designed to clear the fundamentals of the students related to robot anatomy, gripers, basic concepts along with number systems, and control systems which are essential for learning computations and advanced concepts in robotics.

Course Objectives

1. To provide graduates of mechanical engineering with fundamental knowledge in the field of robotics for advanced graduate studies in the area of Robotics.
2. To prepare graduates of mechanical engineering with comprehensive knowledge of Robotics to enable them to apply the relevant knowledge for the learning upcoming advanced subjects in robotics.
3. To introduce graduates of mechanical engineering with anatomy, grippers, control systems, and applications of robotic systems.

Course Learning Outcomes:

CO	**After the completion of the course, the student should be able to**	**Bloom's Cognitive**	
		level	Descriptor
CO1	**Demonstrate** the fundamentals concepts and knowledge of robotics, grippers, tools used in industrial robots, and control systems.	II	Cognitive (Understand)
CO2	**Illustrate** the robot anatomy, configurations, and applications of the robotic systems.	II	Cognitive (Understand)
CO3	**Explain** the concepts related to the robotics programming	II	Cognitive (Understand)
CO4	**Explain** the concepts related to robot kinematics	II	Cognitive (Understand)

CO-PO Mapping:

CO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3			2				2		2	3	2	
CO2	2	2	2			2						2		3	
CO3	2	2	2											3	2
CO4	2	2	2											3	2

Assessments:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively

Teacher Assessment:

Assessment	Marks
ISE I	10
MSE	30
ISE II	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.

MSE: Assessment is based on 50% of course content (Normally first three modules) ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.	
Course Contents:	
Unit 1:- Introduction to Robotics Basic Concepts such as Definition, Industrial Robots, The Laws of Robotics, Socio-Economic aspect of robotisation. Anatomy of Robots, Classifications of Robots, Robot Configurations & types of Work Volume, Technical specifications of Industrial Robot, Spatial Resolution, Accuracy, Repeatability, Degrees of Freedom, Static and Dynamic properties of Robots.	**(06) Hrs.**
Unit 2:- Grippers and Sensors for Robots Gripper Designs, Different types of grippers and End effector, Selection of grippers, Degrees of Freedom, End Effectors: Grippers, Tools. Force Analysis of Grippers, Innovative Robotic Grippers. Performance terminology,classification of sensors and transducers, Need of sensors in Robotics. Contact and non-contact type switches and proximity sensors- inductive, capacitive, optical, pneumatic, potentiometric, incremental and absolute encoders, tachogenerator; Applications in position, displacement, velocity, force, torque and temperature measurement.	**(06) Hrs.**
Unit 3:- Drives & Control for Robots Drives:- Types of Drives, Actuators and its selection while designing a robot system. Types of transmission systems, Control Systems :- Types of Controllers, Introduction to closed loop control	**(06) Hrs.**
Unit 4:- Robot Kinematics & Dynamics Kinematics :- Transformation matrices and their arithmetic, link and joint description, Denavit - Hartenberg parameters, frame assignment to links, direct kinematics, kinematics redundancy, kinematics calibration, Intrduction to Jacobians, and singularities, Intrduction Trajectory generations.(Theoretical treatment only)	**(06) Hrs.**
Unit 5:- Robotic Programming Languages Methods of robot programming, lead through programming, motion interpolation, branching capabilities, WAIT, SIGNAL and DELAY commands, subroutines, Programming Languages: Introduction to various types such as RAIL and VAL II etc, Features of each type and development of languages for recent robot systems.	**(06) Hrs.**
Unit 6:- AI in Robotics and Applications Introduction to Artificial Intelligence, AI techniques, Need and application of AI. Introudction to ChatGPT, Robot Applications: Material transfer and machine loading/unloading, processing operations assembly and inspection. Concepts of safety in robotics, social factors in use of robots	**(06) Hrs.**
Textbooks: 1. Introduction to Industrial Robotics by Ramachandran Nagarajan Pearson Education India (2016) 2. Fundamentals of Robotics_ Linking Perception to Action (Machine Perception and	

Artificial Intelligence, 54)-Ming Xie, World Scientific Publishing Company (2003)
3. Fundamentals of robotics _ analysis & control-Robert J. Schilling, Asoke K.Ghosh, Prentice-Hall of India (2003)
4. Fundamentals of Robotics Engineering-Harry H. Poole, Springer Netherlands (1989)
5. Mikell P. Groover, Mitchell Weiss, Roger N. Nagel, Nicholas G. Odrey, Industrial Robotics : Technology, Programming & Applications, McGraw–Hill International, 2011.
6. Richard D. Klafter , Thomas A. Chemielewski, Michael Negin, Robotic Engineering : An Integrated Approach , Prentice Hall India, 2002.
7. Saha S K, Introduction to Robotics, McGraw Hill Education (India) Private Limited, 2014.

References:

1. Introduction to Robotics_ Analysis, Control, Applications- Saeed B. Niku ,Wiley (2010)
2. Introduction to Robotics Mechanics and Control- John J.Craig, 3rd edition-Pearson Education, Inc. (2005)
3. Fundamentals of Robotics- David Ardayfio, CRC Press (1987)

Title of the Course: Digital Marketing Course Code: UMEA0601	L 2	T 0	P --	Credit -

Course Pre-Requisite: General Awareness, Innovative and Creative Mindset, Genuine interest towards startup & Business development

Course Description: The course is designed to provide the students suitable management, analytical and people skills specific to the career opportunities in the field of Business Development & Digital Marketing sector. This course has been designed to allow graduates to gain the relevant competencies and skills to give them a competitive advantage in Entrepreneurship development.

Course Objectives:

1. To develop right understanding about the changing digitalization of business environment and role of various types of organizations.
2. To inculcate managerial and entrepreneurial attitude amongst the learners and helps them to become a successful business leader.
3. To enhance leadership attitude, marketing skills, Applied based business learning exposure to work at different levels in an organization for Business Development
4. To learn how to Plan, budget, and optimize digital marketing campaigns in a simulated landscape leading to development of business.
5. To cultivate right mind-set among students for taking right business decisions in their development of professional business life.

Course Outcomes:

CO	After the completion of the course the student should be able to	Bloom"s Cognitive level	Descriptor
CO1	**Relate** the concept of Business Development and Digital marketing describe the role of entrepreneurship within society.	1	Remembering
CO2	**Classify** businesses by type of sector & identify, assess and select digital market opportunities towards business development in various sectors.	2	Understanding
CO3	**Demonstrate** concept of blogging digital payments and social media marketing	3	Applying
CO4	**Demonstrate** Video advertising and webpage designing	3	Applying

CO-PO Mapping:

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

Assessments :
In Semester Examination (ISE) will be for 100 Marks

Assessment	Marks
ISE1	50
ISE2	50
	100

ISE: Assessment is based on presentation of market survey, Business Case presentation through PPT/ Assignments/ Website development etc.

Course Contents:

Module-I:--- Role of Marketing & Sales Management in Business Growth Difference between Sales & Marketing, Domestic and International Markets and business entry strategies. Market Research & Techniques of Exploring potential Target markets (STP; Segmentation-Targeting-Positioning), Shift from Four P‟s to Four C‟s of marketing. Market based pricing and costing, Product life cycle (PLC). B2B & B2C Marketing, Negotiation Skills, Case studies.	**6 Hrs.**
Module-II:--- Digital Marketing Introduction What is marketing? What is Digital Marketing?, Understanding Marketing Process, Understanding Digital Marketing Process. Principles of Digital Marketing, Advantages & Disadvantage, Types & Applications of Digital marketing , Sales and marketing in Digital age, Consumer behavior and Digital marketing Increasing Visibility: What is visibility? Types of visibility, Examples of visibility. Visitors Engagement: What is engagement?, Why it is important Examples of engagement	**6 Hrs.**
Module-III: Social Media Marketing Applications of Social Media: Types of Social Media Marketing, Facebook, Twitter, What‟s app etc., YouTube, Instagram, Demonstration and content development, Live Cases Application: Creation of Blogs, Creation of V-log, YouTube Channels (upload) E-Commerce: Introduction to Digital payments, Awareness of mobile banking, Cashless Transaction using various modes like UPI, Wallets, Cards, AEPS, USSD. Digital Media Laws, Block Chain management	**6 Hrs**
Module - IV:-- Content Development Pay-Per-Click- Understanding different types of PPC, creating compelling search ads and understand how keywords and search queries work together to display and create advertisements. Basics of Video Advertising; Creating Video Campaigns; Measurement & Optimization; Creating & Managing a YouTube Channel; Targeting Video Campaigns, Creating A Simple Website For Your	**6 Hrs.**

Business	

References:

1. Innovations and Entrepreneurship By Peter Drucker Pub: UBS publishers and Distributors Ltd. New Delhi
2. Cherunilam, Fransis. (2018). Business Environment. Mumbai: Himalaya Publication.
3.Poornima M Charantimath, "Entrepreneurship development small business enterprises", Pearson,2013
4.Digital Marketing 2.0 by Dr. Rushen Chahal and Prof. Jayanta Chakraborti, Himalaya Publication House,
5.Digital Marketing by Vandana Ahuja, Oxford University Press
6. Marketing Management-a south asian perspective: Kotler Phillip, Keller Kevin Lane, Koshy Abrahamand Jha Mithileshwar, Pearson
7. Marketing Management-Ramswamy V. S., Namakumari S., Macmil lion Pub lishers India Ltd.
8. Sherlekar S.A.-Modern Business Administration and Management; Himalaya PublishingHouse
9. Business Ethics and Value System: H.C.Mrutunjaya; PHL Learning.
10.Rajgopal, „Rural Marketing", Rawat Publications Jaipur and New Delhi
11. Entrepreneurship & Innovation Management (An Industry Perspective) by R. Gopal and Pradip Manjrekar, Excel Books.
12. The Digital Marketing Handbook: A step-by-step guide for the modern marketer, 1st edition, 2015 Mohit Pawar, Metadoor Press.
13. You Should Test That: Conversion Optimization for More Leads, Sales and Profit or The Art and Science of Optimized Marketing, 1st Edition, 2013Chris Goward, Sybex.
14. Digital Marketing for Dummies - Book by Russ Henneberry and Ryan Deiss.
15. Digital Marketing – Seema Gupta Mcgrawhill Publications.
16. Social Media and Mobile Marketing – Puneet Singh Bhatia – Wiley.

Learning Outcomes: After learning the course the students should be able to

1. Students will learn to analyze the business development, marketing and sales operations and **digital marketing** in real-time delivery.
2. Students will receive cognitive knowledge of the skills required in conducting online research and research on online business and associated markets, as well as in identifying, assessing and selecting digital market opportunities towards business development..
3. Students will be taught to interpret the traditional marketing mix within the context of a changing and extended range of digital strategies and tactics.

Title of the Course: HVAC and Refrigeration Lab, Course Code:UMEC0605	L	T	P	Credit
	-	-	2	1

Course Pre-Requisite:

Applied Thermodynamics, Fluid Mechanics, Heat & Mass Transfer.

Course Description:

Students will be able to conduct trials on refrigeration and air conditioning systems. They will evaluate the performance of the systems further they will able to design HVAC systems.

Course Learning Objectives:

1. To enable the students to perform the experiment and analyze results based on principles of mathematics, science and engineering.
2. To prepare students to use modern tools and techniques in HVAC.
3. To train students with effective communication skill to demonstrate refrigeration/air conditioning theories.
4. To develop skills to fulfill industrial needs.
5. To develop a professional approach to lifelong learning in the refrigeration/ air conditioning.

Course Learning Outcomes:

CO	After the completion of the lab the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Perform the experiments in refrigeration and air-conditioning as per given objectives.	3	Applying
CO2	Analyze different refrigeration and air- conditioning systems with their applications.	4	Analyzing
CO3	Evaluate the performance of different systems under different condition	5	Evaluating

CO-PO Mapping:

CO	PO1	PO2	PO3	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2												2		
CO2		2			3										1	1
CO3	2													2		

Assessments :

Teacher Assessment:

One component of In Semester Evaluation (ISE)

Assessment	Marks
ISE	25

ISE are based on practical performed/ Quiz/ Mini-Project assigned/ Presentation/ Group Discussion/ Internal oral etc.

Course Contents:

Experiment No. 1: Trial on vapour compression refrigeration system. **Aim and Objectives:** To demonstrate vapour compression cycle and to calculate theoretical and actual COP. **Outcomes:**	**02Hrs**

The students will be able to understand the performance of vapour compression refrigeration system	
Experiment No 2: Trial on Heat Pump tutor. **Aim and Objectives:** To study the Mechanical Heat Pump Testing Rig and calculate its Coefficient of Performance (COP). **Outcomes:** The students will be able to understand the performance of Heat pump.	**02 Hrs**
Experiment No 3: Trial on ice plant tutor. **Aim and Objectives:** To study the Ice Plant Testing Rig and calculate its Coefficient of Performance (COP) **Outcomes:** The students will be able to understand the performance of ice plant	**02 Hrs**
Experiment No 4: Trial on air conditioning Tutor **Aim and Objectives:** To study basic need of air conditioning, representation of different air conditioning processes on psychrometric chart and performance of refrigeration system. **Outcomes:** The students will be able to understand the performance of air conditioning system.	**02 Hrs**
Experiment No 5 : Trial on refrigeration tutor **Aim and Objectives:** To study the working of household refrigerator along with different auxiliary systems associated with household refrigerator and its wiring diagram and to evaluate the COP. **Outcomes:** The students will be able to understand the performance of domestic refrigerator.	**02 Hrs**
Experiment No 6 : Trial on Cascade refrigeration tutor. **Aim and Objectives:** To demonstrate cascade system and calculate the COP of system. . **Outcomes:** The students will be able to understand the performance of Cascade refrigeration system.	**02 Hrs**
Experiment No 7: Demonstration and study of accessories and controls used in refrigeration system. **Aim and Objectives:** To demonstration and study of accessories and controls used in refrigeration system **Outcomes:** The students will be able to understand accessories and controls used in refrigeration system	**02 Hrs**
Experiment No 8: **Detailed load calculations and equipment selection for Cold Storage/ Ice Factory/Water Chiller**	

Experiment No 9:
Visit to Cold storage / Ice factory .

Aim and Objectives:
Visit to Cold storage / Ice factory to study the actual practices.

Outcomes:
The students will be able to understand the actual practices followed in refrigeration systems.

Textbooks:

1. C. P. Arora ,"Refrigeration and Air conditioning", Tata McGraw Hill Education Private Limited , third edition,2008
2. Roy J. Dossat "Principles of Refrigeration", Pearson, fourth edition, 2007.
3. Stoecker & Jones, "Refrigeration and Air-conditioning", McGraw Hill Book Company, New York, 1983.
4. Dr. S.N. Sapali "Refrigeration and Air-conditioning", PHI (Second Edition) 2016

References:

1. Wilbert F. Stoecker, Industrial refrigeration handbook, 1st edn., McGraw-Hill Professional Publishing,1998
2. Shan K. Wang, "Handbook of air conditioning and refrigeration" McGraw-Hill international edition, second edition.

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Experiment wise Measurable students Learning Outcomes: At the end of each experiment the students will be able to

1. The students will be able to understand the performance of vapour compression refrigeration system.
2. The students will be able to understand the performance of Heat pump.
3. The students will be able to understand the performance of ice plant
4. The students will be able to understand the performance of air conditioning system.
5. The students will be able to understand the performance of domestic refrigerator.
6. The students will be able to understand the performance of Cascade refrigeration system.
7. The students will be able to understand accessories and controls used in refrigeration system.
8. The students will be able to understand the actual practices followed in refrigeration systems.

Title of the Course: Power Plant Engineering Lab Course Code: UMEC0606	L	T	P	Credit
	0	0		

Course Pre-Requisite: Applied Thermodynamic, Basic Mechanical Engineering, Heat Mass Transfer.

Course Description:
This course deals with demonstration of different engine components and systems and conduct of various experiments on engine performance in terms of power, energy utilization and exhaust emissions, its relation to internal processes like combustion and gas exchange at varying engine operating conditions.

Course Objectives:
1. To demonstrate the basic engine components and systems.
2. To train the students to measure different engine performances and apply the knowledge to solve real life problems.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Classify different power plants.	II	Understanding
CO2	Classify and demonstrate different I. C. Engine system.	II	Understanding
CO3	Measure the performance parameters of I. C. Engine.	III	Applying

CO-PO Mapping:

CO	PO1	PO2	PO3	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3											2		
CO2	3													
CO3		3												
CO4		3											2	

Assessments :
Teacher Assessment:
One component of In Semester Evaluation (ISE) and one End Semester Examination (ESE) having 50%, and 50% weights respectively.

Assessment	Marks
ISE	50
ESE	50

ISE are based on practical performed/ Quiz/ Mini-Project assigned/ Presentation/ Group Discussion/ Internal oral etc.
ESE: Assessment is based on oral examination

Course Contents:	
Experiment No. 1:--- Study and demonstration of different types of power plants.	2 **Hrs.**
Experiment No. 2:--- Study and Demonstration of Engine systems: Air intake, Exhaust, Cooling, Lubrication systems.	2 **Hrs.**
Experiment No. 3:--- Study and Demonstration of fuel supply system in I.C. engine.	2 **Hrs.**
Experiment No. 4:--- Study and Demonstration of Ignition system and starting system.	2 **Hrs.**
Experiment No. 5:--- Heat Balance sheet on Petrol/Diesel engine.	2 **Hrs.**
Experiment No. 6:--- Morse test on Petrol/Diesel engine.	2 **Hrs.**
Experiment No. 7:--- Variable speed test on Petrol/Diesel engine.	2 **Hrs.**
Experiment No. 8:--- Test on computerized Variable compression Ratio Engine.	2 **Hrs.**
Experiment No. 9:--- Industrial Visit to Steam or gas power plant.	2 **Hrs.**
Experiment No. 10:--- Industrial visit to engine manufacturing company.	2 **Hrs.**

Textbooks:

1. A Course in Power Plant Engineering, S.C. Arora and S. Domkundwar, Dhanpat Rai, 1988
2. "Internal Combustion Engines", V. Ganesan, Tata McGraw Hill Publication.
3. "Internal Combustion Engines" Mathur and Sharma, Dhanpat Rai Publication , Delhi.
4. A Text Book of Power Plant Engineering, R. K. Rajput, Laxmi Publications, New Delhi.

References:

1] "Internal Combustion Engines", J. B. Heywood,Tata McGraw Hill Publication .
2] "Internal Combustion Engines",Maleev, CBS Publication and Distributors.
3]"Internal Combustion Engines",Gills and Smith , Oxford and IBH Publishing Company

Experiment wise Measurable students Learning Outcomes:

1. Identify different components of I. C. Engines.
2. Demonstrate and explain different engine systems.
3. Explain different components and types fuel supply system.
4. Explain different ignition system and starting system of petrol engine.
5. Demonstrate performance parameters and prepare heat balance sheet of Diesel engine.

6. Determine mechanical efficiency of Petrol/Diesel engine.
7. Understand load and speed characteristics of Petrol/Diesel engine.
9. Understand the working of steam or gas power plant.
10. Demonstrate engine components, assembly and testing.

Title of the Course: MECHATRONICS AND INDUSTRY 4.0 LAB	L	T	P	Credit
Course Code: UMEC0607	-	-	2	1

Course Pre-Requisite: Knowledge of basic Electronics and Electrical Engineering, Sensor and Actuator lab.

Course Description: Studying the mechatronics course is of important due to the global demand and developments in Mechatronic systems, Industry 4.0 and automated manufacturing planning and controlling activities etc. Mechanical systems are becoming smart and for designing and developing such smart systems students of mechanical engineering must understand the basic elements of smart systems such as sensors, signal conditioning devices, microcontrollers, microprocessors, digital logic and programs for automating the processes.

Course Learning Objectives:

CLO1: To provide graduates of mechanical engineering with fundamental skills in the field of mechatronics for advanced graduate studies in the area of Mechatronics, Manufacturing engineering, and related field

CLO2: To stimulate students for developing simple mechatronics applications.

CLO3: To introduce graduates of mechanical engineering with working principles and functioning of basic components, inputs, outputs and programming languages used in mechatronic systems.

Course Learning Outcomes:

CO	After successful completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	**Make use of** Microcontrollers to **demonstrate** applications of mechatronics systems.	III	Application
CO2	**Solve** scenarios of automating the processes by **performing** PLC programming.	III	Application
CO3	**Demonstrate** technologies and concepts related to Industry 4.0.	II	Understanding
CO4	**Develop** a small application of the Mechatronic system.	VI	Create

CO-PO, PSO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	2								2	1	1
CO2	2	3	2	1	2								2	2	2
CO3	2	2	3	1	2								2	1	2
CO4	2	3	3	1	2				2		2		2	3	2

1: Low 2: Medium 3: High

Assessments:

Teacher Assessment:

One component of In Semester Evaluation (ISE)

Components	Marks
ISE	25

ISE are based on laboratory performance and journals.

Minimum 08 experiments to be performed and included in the journal. Students must Fabricate Simple Mechatronics working project using hardware like sensors, signal conditioning, actuators, and suitable software

Course Contents:	Hours
Experiment No.1: --- Addition and Subtraction of 8-bit numbers using microcontroller 8051	**02**
Experiment No. 2: --- LED interfacing with Arduino	**02**

Experiment No. 3: --- Digital Sensor interfacing with Arduino	**02**
Experiment No. 4: --- Analogue Devices interfacing with Arduino.	**02**
Experiment No. 5: --- PLC programming for demonstrating applications of Logic gates.	**02**
Experiment No. 6: --- Applications based on timers using PLC ladder programming.	**02**
Experiment No. 7: --- Applications based on counters using PLC ladder programming.	**02**
Experiment No. 8: --- Real-life application solving using PLC ladder programming.	**02**
Experiment No. 9: --- Demonstration of SMART MACHINE TOOL in Industry 4.0 Lab.	**02**
Experiment No. 10: --- Demonstration of Additive Manufacturing system.	
Experiment No. 11: --- Demonstration of Augmented Reality and Virtual Reality (ARVR) Lab.	**02**
Experiment No. 12: --- Fabrication of Simple Mechatronics working project by a group of 4/5 students using hardware like sensors, signal conditioning, actuators, and suitable software.	

Textbooks:

1. "Mechatronics",W. Bolton, Pearson Education , 4th Edition,
2. "Mechatronics",Mahalik, TATA McGraw Hill, (2006) Reprint,
3. "Microprocessor 8085", Gaokar Prentice Hall of India, 5th Edition.
4. "The 8051 Microcontroller -A System Approach", by Muhammad A. Mazidi, 1st Ed., PH
5. "Introduction to PLC Programming" NIIT.
6. "Programmable Logical Controller", Hackworth, Pearson Education, (2008).
7. "Programmable Logical Controller", Reis Webb, Prentice Hall of India 5th Edition.
8. "MEMS and Microsystems", HSU Tairan, TATA McGraw Hill Publication. 1st Edition.
9. "Industry 4.0: Managing The Digital Transformation", by Alp Ustundag, Springer Publication.

References:

1. "Mechatronics", AppuKuttam, Oxford Publications, 1st Edition.
2. "Automated Manufacturing Systems",S. Brain Morris, Tata McGraw Hill.
3. "Mechatronics and Microprocessor", Ramchandran, Willey India, (2009).
4. "Mechatronics: Integrated Mechanical Electronic System", Ramchandran, Willey India,1st Edition.
5. "Programmable Logical Controller",Gary Dunning Cengage Learning, 3rd Edition.s

Experiment wise Measurable students Learning Outcomes:

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1. The student will be able to perform addition and subtraction of two 8-bit numbers using assembly language programming of microcontroller 8051.
2. The student will be able to interface LED with Arduino.
3. The students will be able to interface Digital Device with Arduino.
4. The students will be able to interface Analog Device with Arduino
5. The students will be able to demonstrate their knowledge of digital logic and apply it to ladder programming.
6. The students will be able to perform ladder programming for given scenarios.
7. The students will be able to perform ladder programming for given scenarios.
8. The students will be able to perform ladder programming for given scenarios.

9. The students will be able to identify the main key components of Industry 4.0
10. The students will be able to identify the main components of additive manufacturing system.
11. The students will be able to know about ARVR.
12. The students will be able to develop simple mechatronics applications to solve real- life problems.

Title of the Course: VIBRATION MEASUREMENTAND CONDITION MONITORING LAB Course Code: UMEC0608	L	T	P	Credit
	-	-	02	01

Course Pre-Requisite: Basics of mathematics, physics, Dynamics of Machines

Course Description: In industry, it is require to monitor the condition of equipments to avoid doen time of machines and hence improve productivity of plant.There are many maintenance strategies in which condition monitoring using vibrations is most imprtant. The subject contain basics of condition monitoring and various techniques used such as vibration analysis, motor signature analysis, NDT methods etc. The subject imphsises on practical approach of condition monitoring.

Course Objectives:

1. To take overview of basic concepts of maintenance and condition monitoring.
2. To study vibration analysis of rotating elements for condition monitoring.
3. To acquaint students with the vibration measuring instruments and condition monitoring.
4. To acquaint students with other techniques of condition monitoring

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Explain fundamentals of vibration measurement, maintenance strategies and condition monitoring.	II	Understanding
CO2	Idetify fault and state condition of rotating equipment.	III	Applying
CO3	Analyze response of mechanical system and provide corrective action.	IV	Analyze
CO4	Develop condition monitoring system for given equipment.	V	Design

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3											3	2		
CO2	2	3	1									2	1	2	
CO3	2	2	2	2	1							1	1	1	1
CO4		3	2	1										1	2

1:low, 2: medium, 3:high

Assessments :

Teacher Assessment:

One component of In Semester Evaluation (ISE) having 100% weightage.

Assessment	Marks
ISE	25

ISE are based on practical performed/ Quiz/ Mini-Project assigned/ Presentation/ Group Discussion/ Internal oral etc.

LABORATORY CONTENT

Experiment 1 : Study of forced vibration and support excitation.

Experiment 2 : Study and demonstration of vibration measuring instruments and exciters.

Experiment 3 : Study of maintenance strategies and role of FMECA in maintenance.

Experiment 4 : Study of signal analysis, filtering and data acquisition.

Experiment 5 : Study and demonstraion of of FFT analyser.

Experiment 6 : Case study of Bearing fault analysis using vibration measurement

Experiment 7 : Case study of Gear box fault analysis using vibration measurement

Experiment 8 : Noise measurement of various rotating elements and identify their condition.

Experiment 9 : Case study of motor current signature analysis technique.

Experiment 10 : Study and demonstration of NDT methods used for condition monitoring.

Textbooks:

1. "Mechanical Vibrations", Singiresu S.Rao , Pearson Education,
2. Machinary Condition Monitoring: Principles and Practices, A.R.Mohanty,CRC Press, 2014
3. "Mechanical Vibrations", G. K. Grover, Published by Nemchand and Brothers, Roorkee.
4. "Mechanical Vibrations", Dr. V. P. Singh, Published by S. Chand and Sons New Delhi.
5. "Noise and Vibration Control", Leo L. Bernack, Tata Mc- Graw Hill Publication.
6. "Mechanical Vibration and Noise Engineering",A. G. Ambekar, Prentice Hall of India.
7. "Fundamentals of Vibrations", Balchandran Magrab ,Cengage Learning.
8. "Theory of Vibrations with Applications", W. Thomson, Pearson Education,2nd Edition.
9. "Mechanical Vibration",Dr Debabrata Nag, Wiley India Pvt. Ltd ,ISBN 978-81-265-3090-

References:

1. "Mechanical Vibration",Austin Church, Wiely Eastern. 2nd Edition.
2. "Schaumm's Outline series in Mechanical Vibration", S. Graham Kelly, 6th Edition.
3. "Kinematics, Dynamics and Design of Machinery",Waldron, Willey India, 2nd Edition.

4. “Mechanical Vibrations”, J.P. Den Hartog, Tata McGrawhill Book Company Inc., 4th Edition.
5. “Introduction to Dynamics and Control”, Leonard Meirovitch, J. Wiley, New York.
6. “Elements of Vibration Analysis” Leonard Meirovitch, Tata McGrmv-Hill, New York. 2nd Edition.
7. “Principles of Vibration”,Benson H. Tongue,Oxford University Press., 4th Edition.
8. “Vibrations and Noise for Engineers”, Kewal Pujara Dhanpat Rai and Sons, (1992).
9. “Mechanical vibration”, William J Palm III Wiley India Pvt. Ltd., ISBN 978-81-265-3168-4, 1st Edition.
10. “Fundamentals of vibrations”, Leonard Meirovitch, McGraw Hill International Edition.11 “Principles of Vibration Control”, . Asok Kumar Mallik, Affiliated East-West Press.
12 “Mechanical Vibrations”, A.H. Church, John Wiley and Sons, Inc, New York, 1994.

Title of the Course: Project Lab-III	L	T	P	Credit
Course Code:UMEC0609	0	0	2	1

Course Pre-Requisite: Basic sciences, mechanical engineering science

Course Description: This course provides an opportunity to students to work on real life problems related to identified course and to provide optimum solution to them. This approach is known as student's centric learning. Because of this way of learning, improvement in important process skills like problem solving ability, critical thinking, team working, communication skills and self learning abilities can be achieved.

Course Objectives:

1. To have a focus on long-term, multidisciplinary, and student-centered project-based learning activities.
2. To foster autonomous and collaborative learning by using resources to solve problems from the real world.
3. Possessing the ability to create software based on the principles of mechanical engineering, mostly by utilizing previously acquired information.
4. To gain hands-on experience in the specification, design, implementation, and testing phases of the mechanical system development life cycle.
5. To gain an ability to choose and use the proper mechanical engineering concepts while designing and evaluating a particular mechanical system.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to
CO1	**IDENTIFY** the real-world problems (related to identified multicourse level PBL) through a rigorous literature survey and formulate / set relevant aims and objectives
CO2	**PROPOSE** a suitable solution based on the fundamentals of mechanical engineering by possibly integration of previously acquired knowledge.
CO3	**ANALYZ**E the results and arrive at valid conclusions
CO4	**USE** of technology in proposed work and demonstrate learning in oral and written form.
CO5	**DEVELOP** ability to work as an individual and as a team member.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P011	PO12	PSO1	PSO2	PSO3
CO1	2	1	1									2	2	2	2
CO2	2	2	2								2	2	2	2	2
CO3		2	2	1								2			
CO4					1			2		2		2			
CO5									2			2			2

Assessments :

Teacher Assessment:

Assessment	Marks
In Semester Evaluation (ISE)	25

ISE are based on multicourse level PBL Project assigned/Models preparation/ Presentation/ Group Discussion/ etc.

Course Contents:

Preamble:

Worldwide, engineering education is currently going through considerable structural changes. The engineering curriculum must be regularly revised in light of emerging topics and with a

multidisciplinary focus due to the fast changing technological landscape. In order to include these fresh themes into educational programs while maintaining the development of traditional abilities, it is required to develop, execute, and assess creative pedagogical approaches. In this setting, interest in project-based learning strategies is quickly growing across the educational community.

The typical classroom teaching method used in the majority of engineering programs places a strong emphasis on lectures and gives students little (if any) control over how they will learn. However, the rapid advancement of engineering and technology necessitates the adoption of a teaching strategy that would help students not only build a foundation of abilities relevant to their business, but also prepare them for future career choices.

Group Structure:

Working in supervisor/mentor –monitored groups. The students plan, manage and complete a task/project/activity which addresses the stated problem.

1. Create groups of 4-6 students in each class.
2. A supervisor/mentor teacher is assigned to 4-6 groups or one batch.

Project Selection:

Suitable project should be identified with respect to the problem statements related with identified ***multicourse level PBL course. (Mechatronics System)***

A survey of journal articles, patents, or a field visit can be used to choose the project. Problems can be theoretical, practical, social, technical, symbolic, cultural, or scientific. The issue must have the following components: an analysis of the issue, design and development of the system, and the viability of finding a solution (hardware or virtual).

It is advised to "learn by doing" in order to solve problem-based initiatives. The concept starts with the identification of an issue, which frequently develops from a query or "wondering." Then, this defined problem serves as the foundation for learning. Students' exploration of many academic fields and professional settings results in problems that can be theoretical, practical, social, technical, symbolic, cultural, and/or scientific in nature.

Ethical Practices, teamwork and project management:

Use Indian standards or any relevant standards for project manufacturing, respect the time of others, attend the reviews, poster presentation and model exhibitions, strictly follow the deadline of project completion, comply with all legislation requirements that govern workplace health and safety practices.

Guidelines for students:

Students should do survey and identify needs, which shall be converted into problem statement for mini project in consultation with faculty supervisor/head of department/internal committee of faculties.

- Students hall submit implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of mini project.
- A log book to be prepared by each group, wherein group can record weekly work progress, guide/supervisor can verify and record notes/comments.
- Faculty supervisor may give inputs to students during mini project activity; however, focus shall be on self-learning.
- Students in a group shall understand problem effectively, propose multiple solution and select best possible solution in consultation with guide/ supervisor.
- Students shall convert the best solution into working model using various components of their domain areas and demonstrate.
- The solution to be validated with proper justification and report to be compiled in standard Format.

Evaluation & Continuous Assessment

The comprehensive and ongoing monitoring and evaluation of student achievement is key to

the PBL concept's effectiveness. It is recommended that regular reporting of all actions be mandated. Students must maintain a PBL log book at the department with regular evaluations of their PBL work. The following should be recorded in the PBL log book:

1. Student guidance and information
2. The PBL guide's weekly oversight,
3. Evaluation form for the PBL guide to review the PBL work

Recommended parameters for assessment, evaluation and weightage:

1. Idea Inception (kind of survey). (10%)
2. Documentation (Gathering requirements, design & modeling, implementation/execution, use of technology and final report, other documents). (15%)
3. Attended reviews, poster presentation and model exhibition. (10%)
4. Demonstration (Poster Presentation, Model Exhibition etc). (10%).
5. Awareness /Consideration of - Environment/ Social /Ethics/ Safety measures/Legal aspects. (5%)
6. Outcome (physical model/prototype/ virtual model/ product development/ assembly & disassembly and analysis of standard mechanism or system, design and development of small application, design of control systems, development of various systems/ /Hackathon/ application development and similar activities/ System performance and analysis) (40%)
7. Participation in various competitions/ publication/ copyright/ patent) (10%)

The review/ progress monitoring committee shall be constituted by head of departments of each institute.

The progress of mini project to be evaluated on continuous basis, minimum two reviews in each semester.

• In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.

• **Distribution of Term work marks for both semesters shall be as below;**

o Marks awarded by guide/supervisor based on log book : 10
o Marks awarded by review committee : 10
o Quality of Project report : 05

Mini Project shall be assessed based on following points;

- ✓ Quality of problem and Clarity
- ✓ Innovativeness in solutions
- ✓ Cost effectiveness and Societal impact
- ✓ Full functioning of working model as per stated requirements
- ✓ Effective use of skill sets
- ✓ Effective use of standard engineering norms
- ✓ Contribution of an individual's as member or leader
- ✓ Clarity in written and oral communication

Reference Books / Research Articles:

1. John Larmer, John R. Mergendoller, and Suzie Boss, "Setting the Standard for Project Based Learning"
2. John Larmer and Suzie Boss, "Project Based Teaching: How to Create Rigorous and Engaging Learning Experiences" 3. Erin M. Murphy and Ross Cooper, "Hacking Project Based Learning: 10 Easy Steps to PBL and Inquiry".
3. Shinde,V.,(2014).Design of Course Level Project Based Learning Models for an Indian Engineering Institute: An assessment of students' learning experiences and learning outcomes .Institute for Planning, Aalborg University, 2014.
4. Vikas V Shinde and S S Inamdar. (2013). Problem Based Learning (PBL) for Engineering Education in India: Need and Recommendations. Wireless Peers Communication, 69, 1097-1105.