



Curriculum & Syllabi

B. Tech. – Mechanical Engineering (as per regulations VTR UGE 2021)

Revised in 36th Board of Studies Meeting
on 05th Jan 2023

DEPARTMENT OF MECHANICAL ENGINEERING
SCHOOL OF MECHANICAL & CONSTRUCTION

Vision

To create, translate and disseminate frontiers of knowledge embedded with creativity and innovation for a positive transformation of emerging society.

Mission

To nurture excellence in teaching, learning, creativity and research; translate knowledge into practice; foster multidisciplinary research across science, medicine, engineering, technology and humanities; incubate entrepreneurship; instill integrity and honour; inculcate scholarly leadership towards global competence and growth beyond self in a serene, inclusive and free academic environment

VISION AND MISSION OF THE DEPARTMENT

Vision

To be a centre of excellence for education and research in the field of Mechanical Engineering to meet the national as well as global challenges.

Mission

- To educate and enrich effective and responsible engineers for national as well as global requirements by providing quality education.
- To maintain vital state of the art research facilities to provide its students and faculty with opportunities to create, interpret, apply and disseminate knowledge.
- To develop linkages with the world class organizations and educational institutions in India and abroad for excellence in teaching, industry and research.
- To cultivate and promote entrepreneurship using industry and R&D facilities of the university.

DEPARTMENT OF MECHANICAL ENGINEERING

B. TECH-MECHANICAL ENGINEERING

PROGRAM EDUCATIONAL OBJECTIVES

The Programme Educational Objectives are to prepare students to:

1. Apply modern analytical, computational, simulation tools and techniques on engineering materials, thermal sciences, applied mechanics and manufacturing methods to address the global challenges faced in mechanical and allied engineering streams.
2. Enable the students in using the techniques of engineering science and their applications to conceive, organize and develop the design of engineering systems.
3. Work as an individual and in teams on multi-disciplinary assignments in industries, research organizations and academic institutions both in national and global level through collaboration.
4. Acquire techno-commercial skills such as research interest and entrepreneurial ability in students to cater the societal problems.

POs & PSOs of B. TECH - MECHANICAL ENGINEERING

- PO1 Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
- PO2 Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
- PO3 Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
- PO4 Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

- PO5 Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
- PO6 The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
- PO7 Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
- PO8 Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
- PO9 Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
- PO10 Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
- PO11 Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
- PO12 Life-long learning: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.
- PSO1 Apply their knowledge in the domains of design, manufacturing and thermal sciences to solve engineering problems using advanced technology.
- PSO2 Engage professionally in industries or as entrepreneurs by applying innovative ideas in design and manufacturing using modern CAD/CAE/CAM tools.

Minimum credits required in course categories

S.No.	Course Category	Minimum Credits Required	
		Regular Students	Lateral Entry Students
1	Foundation Courses	56	22
2	Program Core	58	48
3	Program Elective	18	18
4	Open Elective	12	12
5	Independent Learning	14	14
6	Industry/Higher Institute Learning Interaction	2	2
7	Professional Proficiency Courses	4	4
Total		164	120

Courses exempted for Lateral Entry Students

S.No.	Code	Course	L	T	P	C
1	10211ME103	MATERIALS AND METALLURGY	3	0	0	3
2	10211ME104	ENGINEERING THERMODYNAMICS	2	1	0	3
3	10211ME202	STRENGTH OF MATERIALS	2	1	2	4

PROGRAM CORE COURSES

S.No.	COURSE CODE	COURSE	L	T	P	C
DESIGN DOMAIN						
1	10211ME101	ENGINEERING MECHANICS	3	2	0	4
2	10211ME201	THEORY OF MACHINES	3	0	2	4
3	10211ME202	STRENGTH OF MATERIALS	3	0	2	4
4	10211ME102	MACHINE DESIGN	2	12	0	3
5	10211ME203	FINITE ELEMENT ANALYSIS	2	0	2	3
6	10211ME301	COMPUTER AIDED DESIGN AND DRAFTING	0	0	2	1
MANUFACTURING DOMAIN						
7	10211ME204	MANUFACTURING TECHNOLOGY	3	0	2	4
8	10211ME205	MACHINING AND MACHINE TOOLS TECHNOLOGY	3	0	2	4
9	10211ME103	MATERIALS AND METALLURGY	3	0	0	3
10	10211ME206	MEASUREMENTS AND CONTROL	2	0	2	3
11	10211ME207	MECHATRONICS	3	0	2	4
THERMAL DOMAIN (18 Credits)						
12	10211ME104	ENGINEERING THERMODYNAMICS	2	2	0	3
13	10211ME208	FLUID MECHANICS AND MACHINERY	3	0	2	4
14	10211ME105	APPLIED ENGINEERING THERMODYNAMICS	2	2	0	3
15	10211ME209	THERMAL ENGINEERING	3	0	2	4
16	10211ME210	HEAT AND MASS TRANSFER	3	0	2	4
GENERAL (3 Credits)						
17	10211ME106	SOFT COMPUTING FOR MECHANICAL ENGINEERS	3	0	0	3

PROGRAME ELECTIVE COURSES

S.No.	CODE	COURSE	L	T	P	C
DESIGN DOMAIN						
1	10212ME101	MECHANICS OF COMPOSITE MATERIALS	3	0	0	3
2	10212ME102	TOOL DESIGN ENGINEERING	3	0	0	3
3	10212ME103	INDUSTRIAL TRIBOLOGY	3	0	0	3
4	10212ME104	GEOMETRICAL DIMENSIONS AND TOLERANCE	2	2	0	3

5	10212ME105	CORROSION ENGINEERING	3	0	0	3
6	10212ME106	EXPERIMENTAL STRESS ANALYSIS	3	0	0	3
MANUFACTURING DOMAIN						
7	10212ME107	APPLIED HYDRAULICS AND PNEUMATICS	3	0	0	3
8	10212ME108	JIGS, FIXTURES AND PRESS TOOLS	3	0	0	3
9	10212ME109	NON – DESTRUCTIVE TESTING	3	0	0	3
10	10212ME110	NON TRADITIONAL MACHINING PROCESSES	3	0	0	3
11	10212ME111	PROCESS PLANNING AND COST ESTIMATION	3	0	0	3
12	10212ME112	RAPID PROTOTYPING AND TOOLING	3	0	0	3
THERMAL DOMAIN						
13	10212ME113	INTERNAL COMBUSTION ENGINES	3	0	0	3
14	10212ME114	FUELS AND COMBUSTION	3	0	0	3
15	10212ME115	COMPUTATIONAL FLUID DYNAMICS	3	0	0	3
16	10212ME116	REFRIGERATION AND AIR CONDITIONING	3	0	0	3
17	10212ME117	RENEWABLE SOURCES OF ENERGY	3	0	0	3
18	10212ME118	GAS DYNAMICS AND JET PROPULSION	3	0	0	3
19	10212ME119	AUTOMOBILE ENGINEERING	3	0	0	3
ADVANCED TECHNOLOGY						
20	10212ME201	ADVANCED 3D MODELLING USING UNIGRAPHICS NX	3	0	0	3
21	10212ME120	FINITE ELEMENT MODELLING OF COMPOSITE STRUCTURES	3	0	0	3
22	10212ME121	INTEGRATED PRODUCT DESIGN AND PROCESS DEVELOPMENT	3	0	0	3
23	10212ME202	FINITE ELEMENT ANALYSIS OF MECHANICAL SYSTEMS	2	0	2	3
24	10212ME203	SURFACE MODELLING AND ASSEMBLY	2	0	2	3
25	10212ME122	METAL CASTING TECHNOLOGY	3	0	0	3
26	10212ME123	ADVANCED METAL FORMING PROCESSES	3	0	0	3
27	10212ME124	ADVANCED METAL JOINING PROCESSES	3	0	0	3
28	10212ME125	IOT IN MANUFACTURING	3	0	0	3
29	10212ME126	MICROMACHINING AND MANUFACTURING	3	0	0	3
30	10212ME127	NANO MATERIALS AND APPLICATIONS	3	0	0	3
31	10212ME128	ARTIFICIAL INTELLIGENCE SYSTEM IN MANUFACTURING	3	0	0	3
32	10212ME129	ENGINEERING APPLICATIONS OF PUMP	3	0	0	3

33	10212ME130	DESIGN OF ROTODYNAMIC PUMPS	3	0	0	3
34	10212ME131	SOLAR ENERGY ENGINEERING	3	0	0	3
GENERAL						
35	10212ME132	INDUSTRIAL ENGINEERING AND MANAGEMENT	3	0	0	3
36	10212ME133	TOTAL QUALITY MANAGEMENT	3	0	0	3
37	10212ME134	SUPPLY CHAIN MANAGEMENT	3	0	0	3
38	10212ME135	MAINTENANCE ENGINEERING	3	0	0	3
39	10212ME136	OPERATIONS RESEARCH	3	0	0	3
40	10212ME137	MACHINE LEARNING FOR MECHANICAL ENGINEERS	3	0	0	3
41	10212ME138	THERMAL MANAGEMENT FOR AUTOMOTIVE APPLICATIONS	3	0	0	3

Program Electives

Specialization: **ARTIFICIAL INTELLIGENCE AND ROBOTICS**

S.No.	COURSE CODE	COURSE (ARTIFICIAL INTELLIGENCE)	L	T	P	C
1.	10212ME139	INTRODUCTION TO ARTIFICIAL INTELLIGENCE*	3	0	0	3
2.	10212ME140	FUNDAMENTALS OF MACHINE LEARNING	3	0	0	3
3.	10212ME141	ETHICAL AND SOCIAL IMPLICATIONS OF ARTIFICIAL INTELLIGENCE	3	0	0	3
4.	10212ME142	ARTIFICIAL INTELLIGENCE AND DESIGN THINKING	3	0	0	3
5.	10212ME204	INDUSTRIAL APPLICATIONS OF ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING*	1	0	2	2
6.	10212ME143	FUNDAMENTALS OF COMPUTER VISION	3	0	0	3
COURSE (ROBOTICS)			L	T	P	C
1.	10212ME144	INTRODUCTION TO ROBOTICS*	3	0	0	3
2.	10212ME145	MICROPROCESSOR AND MICROCONTROLLER	3	0	0	3
3.	10212ME146	SENSORS AND ACTUATORS FOR ROBOT OPERATION	3	0	0	3
4.	10212ME147	DESIGN OF ROBOT WITH ARTIFICIAL INTELLIGENCE	3	0	0	3
5.	10212ME148	DYNAMICS AND KINEMATICS OF ROBOTS	3	0	0	3
6.	10212ME149	APPLICATIONS OF ROBOTS*	3	0	0	3

* - mandatory courses

Specialization: **MECHATRONICS**

Sl. No.	COURSE CODE	COURSE	L	T	P	C
1	10212ME150	MICROPROCESSOR AND MICROCONTROLLER	3	0	0	3
2	10212ME151	EMBEDDED SYSTEM AND DEVICE DRIVERS	3	0	0	3
3	10212ME152	SENSORS AND ACTUATORS	3	0	0	3
4	10212ME153	DRIVES AND CONTROLS FOR AUTOMATION	3	0	0	3
5	10212ME154	INDUSTRIAL ROBOTICS	3	0	0	3
6	10212ME155	AUTOMOTIVE ELECTRONICS	3	0	0	3
7	10212ME156	MICRO ELECTRO MECHANICAL SYSTEMS	3	0	0	3
8	10212ME157	FACTORY AUTOMATION	3	0	0	3
9	10212ME158	FLEXIBLE MANUFACTURING SYSTEMS	3	0	0	3
10	10212ME159	INTELLIGENT MANUFACTURING TECHNOLOGY	3	0	0	3

OPEN ELECTIVE COURSES

S.No.	COURSE CODE	COURSE	L	T	P	C
1	10213ME101	COMPOSITES AND POLYMERS	3	0	0	3
2	10213ME102	INTEGRATED PRODUCT DEVELOPMENT	3	0	0	3
3	10213ME103	PRODUCT DESIGN AND ENTREPRENEURSHIP	3	0	0	3
4	10213ME104	IPR AND PATENT RIGHTS	3	0	0	3
5	10213ME105	3D PRINTING AND TOOLING	3	0	0	3
6	10213ME106	MEMS AND NANO TECHNOLOGY	3	0	0	3
7	10213ME107	INDUSTRIAL NANOTECHNOLOGY	3	0	0	3
8	10213ME108	INDUSTRY 4.0	3	0	0	3
9	10213ME201	MATLAB FOR ENGINEERS	2	0	2	3
10	10213ME109	EXPERIMENTAL DESIGN, OPTIMIZATION AND VALIDATION	3	0	0	3
11	10213ME110	SOLAR THERMAL TECHNOLOGY	3	0	0	3
12	10213ME111	ENERGY CONSERVATION AND AUDIT	3	0	0	3
13	10213ME112	ENERGY MANAGEMENT	3	0	0	3
14	10213ME113	GREEN ENGINEERING AND SUSTAINABILITY	3	0	0	3
15	10213ME114	FACILITY LAYOUT AND MATERIAL HANDLING	3	0	0	3
16	10213ME115	INDUSTRIAL SAFETY, HEALTH AND HAZARDS	3	0	0	3
17	10213ME116	OPTIMIZATION TECHNIQUES	3	0	0	3

B.Tech. HONORS

S.No.	COURSE CODE	COURSE	L	T	P	C
Theme 1: Digital Manufacturing						
1	10212ME160	AUTOMATION IN MANUFACTURING AND CIM	3	0	0	3
2	10212ME161	COMPUTER AIDED DESIGN AND MANUFACTURING	3	0	0	3
3	10212ME162	PRECISION ENGINEERING	3	0	0	3
4	10212ME163	INDUSTRY 4.0 AND IOT	3	0	0	3
5	10212ME164	ADDITIVE MANUFACTURING	3	0	0	3
6	10212ME165	INTELLIGENT MANUFACTURING SYSTEMS	3	0	0	3
7	10212ME166	MANUFACTURING SYSTEMS AND SIMULATION	3	0	0	3
8	10212ME167	MANUFACTURING INFORMATION SYSTEMS	3	0	0	3

S.No.	COURSE CODE	COURSE	L	T	P	C
Theme 2: Computational Thermo Fluids						
1	10212ME168	ADVANCED FLUID MECHANICS	2	1	0	3
2	10212ME169	COMPUTATIONAL HEAT TRANSFER AND FLUID FLOW	3	0	0	3
3	10212ME170	COMPUTATIONAL MODELING OF MULIPHASE AND REACTING FLOWS	3	0	0	3
4	10212ME171	MODELING OF COMBUSTION AND EMISSION CHARACTERISTICS	3	0	0	3
5	10212ME172	DECISION MAKING IN LARGE SCALE SYSTEMS	3	0	0	3
6	10212ME173	DESIGN AND OPTIMIZATION OF THERMO FLUID SYSTEMS	3	0	0	3
7	10212ME205	COMPUTATIONAL ANALYSIS OF THERMO FLUID SYSTEMS	2	0	2	3

B.Tech. WITH MINOR SPECIALIZATION

S.No.	COURSE CODE	COURSE	L	T	P	C
Theme 1: Smart Manufacturing						
1	10213ME202	COMPUTER AIDED PRODUCT DESIGN	2	0	2	3
2	10213ME203	FINITE ELEMENT ANALYSIS USING ANSYS	2	0	2	3
3	10213ME204	MANUFACTURING SIMULATION USING CNC CODES	2	0	2	3
4	10213ME117	PRACTICAL ASPECTS IN ADDITIVE MANUFACTURING	3	0	0	3
5	10213ME118	DIGITAL MANUFACTURING AND DESIGN	3	0	0	3
6	10213ME119	MACHINE LEARNING FOR INDUSTRY 4.0	3	0	0	3
7	10213ME120	PRODUCT DEVELOPMENT	3	0	0	3

S.No.	COURSE CODE	COURSE	L	T	P	C
Theme 2: Energy Engineering						
1	10213ME121	ENERGY RESOURCES	3	0	0	3
2	10213ME122	ENERGY CONVERSION TECHNIQUES	3	0	0	3
3	10213ME123	ENERGY STORAGE SYSTEMS	3	0	0	3
4	10213ME124	ENERGY EFFICIENT BUILDINGS	3	0	0	3
5	10213ME125	INSTRUMENTATION IN ENERGY SYSTEMS	3	0	0	3
6	10213ME126	BIO ENERGY ENGINEERING	3	0	0	3
7	10213ME127	ENERGY MANAGEMENT	3	0	0	3

Program Core

COURSE CODE	ENGINEERING MECHANICS	L	T	P	C
10211ME101		3	2	0	4

1. Preamble

This course provides an introduction to the basic concepts of forces, inertias, centroids, and moments of area and techniques for finding their effects on motion. It introduces the phenomenon of friction and its effects. It introduces students to cognitive learning in applied mechanics and develops problem-solving skills in both theoretical and engineering-oriented problems.

2. Pre-requisite

10210PH103 - Applied Physics

3. Link to the other courses

10211ME201 - Theory of Machines

10211ME202 - Strength of Materials

4. Course Educational Objectives

Students, after undergoing this course would

- Possess the basic knowledge in mechanics in the areas of applied engineering.
- Develop the skills in the areas of forces and their effects and in the concept of free body diagram

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Calculate the equilibrium of particles in space using laws of mechanics.	K3
CO2	Estimate the magnitude of forces and moments acting on 2D & 3D rigid bodies.	K3
CO3	Determine centroid, moment of area, and moment of inertia of solid and surfaces using parallel and perpendicular axis theorem.	K3
CO4	Determine displacement, velocity, acceleration, and impact of elastic bodies under particles in motions.	K3
CO5	Calculate the friction in screw thread, belt drive, and brakes using laws of Coulomb friction and calculate linear and angular acceleration of moving body in general plane motion.	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	L										M	
CO2	H	H	M										M	
CO3	H	H	M										M	
CO4	H	H	M										M	
CO5	H	H	M										M	L

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I BASICS & STATICS OF PARTICLES

L-9 T-6

Introduction – Units and Dimensions – Laws of Mechanics – Lami's theorem, Parallelogram and Triangular Law of forces – Vectors – Vectorial representation of forces and couples – Vector operations: additions, subtraction, dot product, cross product – Coplanar Forces – Resolution and Composition of forces – Equilibrium of a particle – Forces in space – Equilibrium of a particle in space – Equivalent systems of forces – Principle of transmissibility – Single equivalent force.

UNIT II EQUILIBRIUM OF RIGID BODIES

L-9 T-6

Free body diagram – Types of supports and their reactions – requirements of stable equilibrium – Moments and Couples – Moment of a force about a point and about an axis – Scalar components of a moment – Varignon's theorem – Equilibrium of Rigid bodies in two dimensions – Equilibrium of Rigid bodies in three dimensions – Examples.

UNIT III PROPERTIES OF SURFACES AND SOLIDS

L-9 T-6

Determination of Areas and Volumes – First moment of area and the Centroid of sections – Second and product moments of plane area – Parallel axis theorem and perpendicular axis theorem – Polar moment of inertia – Principal moments of inertia of plane areas – Principal axes of inertia – Mass moment of inertia

UNIT IV DYNAMICS OF PARTICLES

L-9 T-6

Displacement, Velocity and Acceleration, their relationship – Relative motion – Curvilinear motion – Newton's laws – Work-Energy Equation of particles – Impulse and Momentum – Impact of elastic bodies.

UNIT V FRICTION

L-9 T-6

Frictional force – Laws of Coulomb friction – simple contact friction – Friction in screw threads, Friction in Belt and rope drives, Friction aspects in Brakes – Band Brake - Block Brake, Roller friction. Translation and Rotation of Rigid Bodies – General Plane motion.

TOTAL: 75 PERIODS

8. Text Books

1. Hibbeler, R.C., Engineering Mechanics, Vol. 1 Statics, Vol. 2 Dynamics, Pearson Education Asia Pvt. Ltd., 2015.
2. S. Timoshenko, D. H. Young, J. V. Rao, SukumarPati, Engineering Mechanics, McGraw Hill Education (India) Private Limited., 2013.

9. References

1. Palanichamy, M. S., and Nagan, S., Engineering Mechanics (Statics and Dynamics), Tata McGraw Hill, New Delhi 2012.
2. Kumar, K. L., Engineering Mechanics, Tata McGraw- Hill, New Delhi, 2011.
3. Shames, I. H., and Krishna Mohana Rao, G., Engineering Mechanics (Statics and Dynamics), Dorling Kindersley India) Pvt. Ltd. (Pearson Education), 2011.
4. Beer, F. P., and Johnston, E. R., Vector Mechanics for Engineers – Dynamics and Statics, Tata McGraw- Hill, New Delhi, 2011.
5. Natarajan, K.V., Engineering Mechanics, Dhanalakshmi Publishers, 2011.
6. Rajasekaran, S. and Sankarasubramanian, G., Engineering Mechanics, Vikas Publishing House Pvt Ltd, 2011.

COURSE CODE	THEORY OF MACHINES	L	T	P	C
10211ME201		3	0	2	4

1. Preamble

This course provides adequate knowledge on the basic components of a mechanism and its kinematics. It enables design of cam mechanisms for specified output motions and solving of problems in toothed gear trains. Also provides the concepts and techniques of force analysis and balancing. It introduces the concepts of vibrations, governors, gyroscopes and develops problem solving skills in engineering problems.

2. Pre-requisite

10211ME101-Engineering Mechanics

3. Link to the other courses

10211ME102-Machine Design

4. Course Educational Objectives

Students, after undergoing this course would

- Gain knowledge on the basic concepts of mechanisms, cam, gears and gear trains and their kinematics and applications.
- Develop the knowledge of complex algebra, vector method, graphical methods and Computational skills in the areas of dynamics.
- Gain knowledge in areas of vibration analyses, balancing unbalanced machines, stabilization of ships and aero planes.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Determine the velocity and acceleration of links in the mechanism using graphical, analytical, and experimental methods.	K3
CO2	Draw cam profile for given follower motions and determine the velocity ratio of the simple, compound, and epicyclic gear trains by conducting experimentation.	K3
CO3	Analyze the dynamic forces and couples on rotating and reciprocating components of machines to compute the magnitude and direction of balancing masses using analytical and experimental methods.	K4
CO4	Compute and Analyse the natural frequency of damped free vibration of mechanical systems using analytical and practical methods.	K4
CO5	Compute the dimensions, sensitivity, and effort of spring-loaded and gravity-type governors and determine the gyroscopic effect on automobile, ship, and aerospace applications.	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	M						M	M			H	L
CO2	H	H	H						M	M			H	L
CO3	H	H	M	L					M	M		M	H	L
CO4	H	H	M	L					M	M		M	H	L
CO5	H	H	H	L					M	M		M	H	L

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I KINEMATICS OF MECHANISMS

L-9 P-6

Introduction to kinematics and mechanisms - Kinematic Link, Kinematic Pair, kinematic diagrams, Gruebler's Criterion for degree of freedom- Grashof's criterion, Kinematic Inversions - Four bar mechanism, Slider- Crank mechanism and double slider mechanism, Mechanical Advantage, Transmission angle.

Analysis of simple mechanisms - Relative velocity method - Velocity and acceleration of four bar and single slider crank mechanism, Analytical methods, Coriolis acceleration.

Experiment 1: Design and develop the following mechanism using the given links

- (a) Crank Rocker (b) Double crank (c) Double Rocker (d) Triple Rocker
(e) Parallelogram (f) Anti-parallelogram and (g) Deltoid

Experiment 2: Find the velocity and accelerations of the given landing gear mechanisms.

Experiment 3: Find the velocity and acceleration of the given quick return mechanism.

UNIT II CAM AND GEAR

L-9 P-6

Cams - classification of cam and followers - displacement diagrams, velocity and acceleration analysis of simple harmonic motion (SHM), uniform velocity, uniform acceleration, cycloidal motion.

Gears-Classification, Terminology, Law of Gearing, Length of path of contact, arc of contact, contact ratio, Interferences. Gear trains - Simple gear train, compound gear train, reverted gear train, planetary/epicyclic gear train - applications.

Experiment 4: Construct the cam profile based on the type of follower motion.

Experiment 5: Construct the cam profile and draw the velocity and acceleration diagram based on the type of follower motion.

Experiment 6: Calculate and experimentally determine the angular velocity ratios of gear trains.

UNIT III FORCE ANALYSIS AND BALANCING

L-9 P-6

Rigid Body dynamics in general plane motion – Equations of motion - Dynamic force analysis - Inertia force and Inertia torque – D'Alembert's principle.

Balancing- Concept of static and dynamic balancing, Balancing of rotating mass by another mass in the same plane, Forces due to revolving masses. Concept of reference plane, balancing of several rotating masses in same plane and different planes. Balancing of reciprocating masses.

Experiment 7: Perform balancing of a rotating masses in the same plane for a given rotor system.

Experiment 8: Perform balancing of a rotating masses in the different plane for a given rotor system.

Experiment 9: Perform balancing of reciprocating masses for a given rotor system.

UNIT IV FREE AND FORCED VIBRATION

L-9 P-6

Basic features of vibratory systems - idealized models - Basic elements and lumping of parameters - Degrees of freedom - Free vibration - Equations of motion - natural frequency - Types of Damping - Damped vibration critical speeds of simple shaft - Torsional systems; Natural frequency of two and three rotor systems.

Harmonic Forcing - Forcing caused by unbalance -Support motion – Force transmissibility and amplitudetransmissibility - Vibration isolation.

Experiment 10: Determination of damping co-efficient of single degree of freedom system.

Experiment 11: Determination of torsional natural frequency of single and Double Rotor systems.

Experiment 12: Transverse vibration for various end condition such as Free-Free, Fixed-FreeFor determination of natural frequency by free and forced vibration test.

UNIT V MECHANISMS FOR CONTROL

L-9 P-6

Governors - Types - Centrifugal governors - Gravity controlled and spring controlled centrifugal governors – Characteristics - Effect of friction - Controlling Force. Gyroscopes - Gyroscopic forces andTorques - Gyroscopic stabilization - Gyroscopic effects in Automobiles, ships and airplanes.

Experiment 13: Determination of gyroscopic couple.

Experiment 14: Determination of sensitivity and effortfor Wattgovernor

Experiment 15: Determination of sensitivity and effortforHartnell governor

TOTAL: 75 PERIODS

8. Text Books

1. Thomas Bevan, "Theory of Machines", Pearson education, Noida, 5th Edition, 2013.
2. Shigley J. E. and Uicker J. J. "Theory of Machines and Mechanisms," McGraw Hill ISE, 2011.
3. Rattan S. S., "Theory of Machines", Tata McGraw Hill, 2014.
4. Rao and Dukkipati, R.V, "Mechanism and Machine Theory", New Age International (P) Ltd., 2010.

9. References

1. P. L. Balleney, "Theory of Machines", Khanna Pub. Delhi, 2012
 2. Singh, V.P., "Theory of Machines", Dhanpat Rai & Co., (P) Ltd., New Delhi, 2011.
 3. Sadhu Singh, "Theory of Machines". Pearson Education, New Delhi, 2009.
 4. Ghosh, A. K. Malik, Theory of Mechanisms and Machines, Affiliated East West Press, 2003.
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COURSE CODE	STRENGTH OF MATERIALS	L	T	P	C
10211ME202		3	0	2	4

1. Preamble

This course provides knowledge of stresses, strains and deformations in components due to various loads. It helps in assessing the stresses and deformations through mathematical models of beams, twisting bars or combinations of both.

2. Pre-requisite

10211ME101 - Engineering Mechanics

3. Link to the other courses

10211ME102 - Machine Design

10211ME203 - Finite Element Analysis

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the basic concepts related tensile, compressive and shear stresses in engineering components.
- Understand the basic principles of torsion in shafts, shear force and bending moment in beams, deflection in springs and beams.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Calculate stress, strain, young's, and rigidity modulus of simple and compound bars under axial loading.	K3
CO2	Analyze experimentally the Torsional stress, angle of twist, and deflections in circular shafts and springs using the torsional equation.	K4
CO3	Draw shear and bending moment diagrams of simple beams subjected to various loading conditions and also experiment double shear test on Mild steel and Aluminium by applying theory of simple bending.	K4
CO4	Calculate slope and deflections of cantilever and simply supported beams using Macaulay and Moment-area methods.	K3
CO5	Compute the longitudinal and hoop stress on thin cylindrical and spherical shells subjected to internal and external pressure.	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	M	L					M	M			M	L
CO2	H	H	H	L					M	M			M	L
CO3	H	H	M						M	M			M	L
CO4	H	H	M		M				M	M			M	L
CO5	H	H	M						M	M			M	L

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I DEFORMATION OF SOLIDS

L-9 P-6

Introduction to Rigid and Deformable bodies - Types of Load, Stress, Strain, Tensile-Stress and Strain, Compressive Stress and Strain - normal stress - Hook law, Shear Stress and Strain, Shear Modulus, Bearing Stress, Stress-strain Diagram, Factor of Safety, Selection of Factor of Safety, Poisson's Ratio, Volumetric Strain-Relation Between Bulk Modulus and Young's Modulus, Relation Between Young's Modulus and Modulus of Rigidity, Impact Stress, stress in simple and composite bars under axial load-Thermal stress - Strain energy.

Experiments: Tension test on a mild steel rod, Impact test on metal specimen, Hardness Testing - Brinnell, Vickers and Rockwell Hardness Tester.

UNIT II TORSION

L-9 P-6

Theory of torsion equation-Torsion of Solid and hollow circular bars - Shear stress distribution-Stepped shaft - Twist and torsion stiffness - Compound shafts - springs - types - helical springs - shear stress and deflection in springs.

Experiments: Torsion test on mild steel rod, Compression test on helical springs, Fatigue test on Aluminium rod.

UNIT III BEAMS

L-9 P-6

Types : Beams, Supports and Loads - Shear force and Bending Moment diagram - Cantilever, Simply supported, Overhanging beam, fixed beam, continuous beam - Theory of simple bending - Stress, Shear stress in beams - Evaluation of 'I', 'L' & 'T' sections.

Experiments: Double shear test on Mild steel and Aluminum rods.

UNIT IV DEFLECTION OF BEAMS

L-9 P-6

Introduction - Evaluation of beam deflection and slope: Cantilever, Simply supported beams- Macaulay Method and Moment-area Method.

Experiments: Deflection test on beams.

UNIT V ANALYSIS OF STRESSES IN TWO DIMENSIONS

L-9 P-6

Biaxial state of stresses - Principal planes and stresses - Mohr's circle for biaxial stresses - Maximum shear stress. Introduction to theories of failure-Stresses in thin cylindrical and spherical shells.

Experiments: Strain Measurement using Rosette strain gauge

TOTAL: 75 PERIODS

8. Text Books

1. Nash W.A, "Theory and problems in Strength of Materials", Schaum Outline Series, McGraw-Hill Book Co, New York, 2014.
2. Timoshenko S.P, "Elements of Strength of Materials", Tata McGraw-Hill, New Delhi 2013.

9. References

1. Popov E.P, "Engineering Mechanics of Solids", Prentice-Hall of India, New Delhi, 2010.

2. Jindal U.C. "Strength of Materials" Asian Books Pvt Ltd, New Delhi 2007.
3. 3. Bansal, R.K., A Text Book of Strength of Materials, Lakshmi Publications Pvt. Limited, New Delhi, 2012
4. Rajput.R.K. "Strength of Materials" ,S.Chand& co Ltd. New Delhi 2012.
5. Khurmi R.S, A Text book of strength of materials, S.Chand& co Ltd. New Delhi 2012

COURSE CODE	MACHINE DESIGN	L	T	P	C
10211ME102		2	2	0	3

1. Preamble

This course provides an introduction to the design procedure for various mechanical components. It introduces the concepts associated with stress and torque calculations of various machine elements such as fasteners, welded joints, shafts, couplings and gear. Apart from this it also gives a detailed view of Design of Brakes, clutches and design of bearings.

2. Pre-requisite

10211ME202-Strength of Materials

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the various steps involved in designing machine components using standard data and practice.
- Create confidence to solve complex problems in the design for various types of fasteners, joints, Shafts-keys, couplings, springs, Gear, breaks and bearings.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Analyze the state of internal effects caused by external loads acting on real bodies that undergo deformation (stress & strain)	K4
CO2	Analyze the Torsional stress and angle of twist in circular shafts used for power transformation using torsional equation.	K4
CO3	Analyze threaded and bolted joints for external loading and Design rigid and flexible couplings for the given specifications using design data book.	K4
CO4	Design spur gear for its beam and wear strength and also design single and multi-speed gearbox for the given specifications and application using design data book.	K4
CO5	Design sliding and rolling contact bearings based on life and calculate the dimensions of plate, cone, and internal & external shoe brakes for the externally applied load.	K4

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	M			L							H	L
CO2	H	H	M			L							H	L
CO3	H	H	H			L						L	H	L

CO4	H	H	H			L		M				L	H	L
CO5	H	H	H			L		M				L	H	L

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I FUNDAMENTALS OF DESIGN

L-6 T-6

Introduction to the design process - Phases of Design - Factors influencing machine design - Direct, Bending and shear stresses – Impact and shock loading - theories of failure – Stress concentration - Calculation of principle stresses for various load combinations, eccentric loading –Design for variable loading.

UNIT II SHAFTS AND DRIVES

L-6 T-6

Design of solid and hollow shafts based on strength, rigidity and critical speed- selection of v belts and pulleys – selection of flat belts and pulleys.

UNIT III FASTENERS AND COUPLINGS

L-6 T-6

Design of Threaded fasteners - Design of bolted joints - Design of welded joints – Design of keys and key ways – Design of rigid and flexible couplings.

UNIT IV DESIGN OF SPUR GEAR AND GEAR BOX

L-6 T-6

Gear Terminology-Speed ratios and number of teeth-Force analysis -Tooth stresses - Dynamic effects -Fatigue strength - Factor of safety - Gear materials – Module and Face width-power rating calculationsbased on strength and wear considerations- Geometric progression - Standard step ratio - Ray diagram, kinematics layout -Design of sliding mesh gear box and Constant mesh gear box - Design of synchromesh gear box. Introduction to gear coating.

UNIT V DESIGN OF BEARINGS, CLUTCHES AND BRAKES

L-6 T-6

Types of bearing- sliding and rolling. Roller and ball bearing – Basic dynamic load rating - Cubic meanload-life in million hours. Design of journal bearings – Mc Kees equation – Lubrication in journal bearings – calculation of bearing dimensions introduction to foil bearing - Design of plate clutches –axial clutches-cone clutches- internal expanding rim clutches-internal and external shoe brakes.

TOTAL: 60 PERIODS

8. Text Books

1. Shigley J., "Mechanical Engineering Design", Mc Graw Hill, 2010.
2. Bhandari V.B, "Design of Machine Elements", Tata McGraw-Hill Book Co, 2010.

9. References

1. Juvinall R. C., Marshek K.M., "Fundamentals of Machine component Design", – John Wiley & Sons Third Edition,2002.
2. Maitra G.M., Prasad L.V., "Hand book of Mechanical Design", II Edition, Tata McGraw-Hill, 2001.
3. U.C.Jindal : Machine Design, "Design of Transmission System", Dorling Kindersley, 2010.
4. Bernard Hamrock, Steven Schmid, Bo Jacobson, "Fundamentals of Machine Elements", 2nd Edition, Tata McGraw-Hill Book Co., 2006.
5. Robert Norton, "Design of Machinery", McGraw Hill, Fifth Edition, 2011.

COURSE CODE	FINITE ELEMENT ANALYSIS	L	T	P	C
10211ME203		2	0	2	3

1. Preamble

This course imparts the knowledge to develop a thorough understanding of the basic principles of the finite element analysis techniques with an ability to effectively use the tools of the analysis for solving practical problems arising in engineering applications.

2. Pre-requisite

10211ME202-Strength of Materials

3. Link to the other courses

Analysis of Mechanical Systems

4. Course Educational Objectives

Students, after undergoing this course would

- Understand how to mathematically model physical systems and solve using numerical techniques.
- Select appropriate element and boundary conditions for various 1D & 2D Boundary value problems.
- Give exposure to software tools needed to analyze engineering problems.
- Expose to different applications of simulation and analysis tools.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Formulate mathematical model for given condition using weighted residual and Ritz techniques.	K5
CO2	Formulate stiffness matrix and solve one-dimensional structural problems (bar and truss) using second-order equation.	K5
CO3	Formulate mathematical modeling and solve two-dimensional Triangular and Quadrilateral elements problems.	K5
CO4	Solve and Experiment 2-Dimensional heat transfer analysis for fins and plate application using ANSYS package.	K3
CO5	Experiment modal, Harmonic, and Transient analysis of beams and springs using ANSYS package.	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	M		M								H	H
CO2	H	H	M		M					M			H	H
CO3	H	H	M		M					M			H	H
CO4	H	H	M	L	M				L	M		M	H	H
CO5	H	H	M	L	M				L	M		M	H	H

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION

L-6 P-6

Mathematical Modeling of field problems in Engineering, Governing Equations, Boundary, Initial and Eigen Value problems, Weighted Residual Methods, Ritz Technique – Basic concepts of the Finite Element Method

Experiments: Demonstration on Ansys Working Environment, Creations of Key points, Lines, Surfaces.

UNIT II ONE-DIMENSIONAL PROBLEMS – BAR & TRUSS ELEMENTS

L-6 P-6

One Dimensional Second Order Equations, Discretization, Element types Linear and Higher order Elements, Derivation of Shape functions and Stiffness matrices and force vectors Assembly of Matrices

Experiments: Force and Stress analysis using link elements in Trusses, cables and bars Stress and deflection analysis in beams with different support conditions.

UNIT III TWO DIMENSIONAL SCALAR VARIABLE PROBLEMS

L-6 P-6

Second Order 2D Equations involving Scalar Variable Functions – Vibrational formulation – Finite Element formulation – Triangular elements and Quadrilateral elements- Shape functions and element matrices and vectors.

Experiments: Stress analysis of flat plates and simple shells. Stress analysis of Axisymmetric components.

UNIT IV APPLICATIONS IN HEAT TRANSFER

L-6 P-6

Heat Conduction: 1-D & 2-D Heat conduction problems, Slabs, fins, Transient Thermal Analysis, Applications for heat conduction and 2D stress analysis

Experiments: Thermal stress and heat transfer analysis of fins, plates.

UNIT V DYNAMIC ANALYSIS USING FINITE ELEMENT METHOD

L-6 P-6

Introduction – vibrational problems – equations of motion based on weak form – longitudinal vibration of bars – transverse vibration of beams – element equations – solution of eigenvalue problems.

Experiments: Modal analysis of Beams. Harmonic, transient analysis of simple systems.

TOTAL: 60 PERIODS

8. Text Books

1. David V. Hutton, "Fundamentals of Finite Element Analysis", Tata McGraw-Hill Edition, 2005.

9. References

1. Rao, S.S., "The Finite Element Method in Engineering", Butterworth-Heinemann (An imprint of Elsevier), reprint 2012, Published by Elsevier India Pvt. Ltd., New Delhi.
2. Reddy, J.N., "Introduction to Non-Linear Finite Element Analysis", Oxford University Press, 2008.
3. Zienkiewicz, O.C, Taylor, R.L., & Zhu, J.Z "The Finite Element Method: Its Basis & Fundamentals", Butterworth-Heinemann (An imprint of Elsevier), 2007, India
4. Cook, R.D., Malkus, D. S., Plesha, M.E., and Witt, R.J " Concepts and Applications of Finite Element Analysis", Wiley Student Edition, 4th Edition, First Reprint 2007, Authorized reprint by Wiley India(P) Ltd., New Delhi.

COURSE CODE	COMPUTER AIDED DESIGN AND DRAFTING	L	T	P	C
10211ME301		0	0	2	1

1. Preamble

This course helps students to easily visualize and see the final product at the design stage itself with the aid of computer. Students will design and draft various parts that are produced in digital and Physical models. Students will obtain extensive experience utilizing CAD softwares.

2. Pre-requisite

10210ME201 - Engineering Graphics

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- To gain practical experience in handling 2D drafting and 3D modelling software systems.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Develop 2D detailed drawings of given mechanical components using AUTOCAD drafting tools and commands.	K3,S3
CO2	Create 3D solid and assembly models of given mechanical components using AUTOCAD tools and commands.	K3,S3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	M	H		H	H		M		M		H	H	H
CO2	L	M	H		H	H		M		M		H	H	H

(H- High; M-Medium; L-Low)

7. Course Content

INTRODUCTION TO 2D DRAFTING

Drawing, Editing, Dimensioning, Layering, Hatching, Block, Array, Detailing, Detailed drawing.

List of Experiments

Bush bearing

Plummer block

Safety Valve and non-return valves.

3D GEOMETRIC MODELING AND ASSEMBLY

Sketcher - Datum planes – Protrusion – Holes - Part modeling – Extrusion – Revolve – Sweep –Loft – Blend – Fillet - Pattern – Chamfer - Round - Mirror – Section – Assembly.

List of Experiments

- Flange Coupling
- Universal Coupling
- Muff Coupling
- Knuckle Joint
- sleeve & cotter joints
- Piston
- connecting rod
- stuffing box
- Screw jack
- Machine vice
- Chuck

TOTAL: 30 PERIODS

COURSE CODE	MANUFACTURING TECHNOLOGY	L	T	P	C
10211ME204		3	0	2	4

1. Preamble

This course provides an introduction to the basic concepts and apply the metal casting processes, joining & deformation processes, special welding processes, powder metallurgy and plastic processing.

2. Pre-requisite

NIL

3. Link to the other courses

10211ME205 - Machining and Machine Tools Technology

Project work

4. Course Educational Objectives

Students, after undergoing this course would

- Acquire knowledge in manufacturing processes of casting, joining, deformation, powder metallurgy, plastic processing and additive manufacturing.
- Knowledge to prepare the sand mould for the casting process and demonstrate the joining of two metals, rolling, FDM & 3D printer machines.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Enumerate the process steps involved in sand & special casting processes and prepare sand moulds with the use of solid, split, and loose piece patterns.	K3
CO2	Choose suitable welding processes (fusion & special welding) for a given precision welding job.	K3
CO3	Illustrate the working principles of hot & cold working of metals and demonstrate the rolling operation to reduce the thickness of the given plate using two high rolling mills.	K4
CO4	Describe the production of metal powder, the working process of sintering, and methods of manufacturing plastic components.	K2
CO5	Outline the operating principles, applications, and materials for additive manufacturing and produce a prototype using 3D printer.	K4

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	H								M			H	
CO2	L	H					L			M			H	
CO3	L	H								M			H	

CO4	L	-								M			H	
CO5	L	H	H	H	H		L			M	M		H	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I METAL CASTING PROCESSES

L-9 P-12

Sand casting – Sand moulds - Type of patterns – Pattern materials – Pattern allowances – Types of Moulding sand – Properties – Core making – Working principle of Special casting processes – Shell – investment casting – Pressure die casting – Centrifugal casting – Stir casting – CO2 process– Sand Casting defects.

Experiments: Preparation of sand mould with solid, Preparation of sand mould with split pattern, Preparation of sand mould with loose piece pattern, Preparation of sand mould with core.

UNIT II JOINING PROCESSES

L-9 P-9

Fusion welding processes – Types of Gas welding – Equipment used – Arc welding equipment's - Gas metal arc welding – TIG and MIG welding process – Principle and application of special welding processes - Resistance welding– Plasma arc welding – Thermit welding – Electron beam welding –laser beam welding.–Ultra sonic welding – Friction welding – Friction stir welding.

Experiments: Joining the two metals using arc welding, Gas welding, TIG welding.

UNIT III DEFORMATION PROCESSES

L-9 P-3

Hot working and cold working of metals – Forging processes – Open, and closed die forging process –Typical forging operations – Rolling of metals – Types of Rolling mills - Principle of rod and wire drawing - Tube drawing – Principles of Extrusion – Types of Extrusion – Hot and Cold extrusion, Sheet metal characteristics – Stretch forming operations – Metal spinning.

Experiments: Reducing the thickness of the plates using rolling machine.

UNIT IV POWDER METALLURGY AND PLASTIC PROCESSING

L-9

Production of metal powder: Atomization, crushing; blending; compacting: Die pressing; sintering: Principle, continuous sintering process; plastic processing: Injection moulding, blow moulding, rotational moulding, Compression moulding and Transfer moulding.

UNIT V ADDITIVE MANUFACTURING

L-9P-6

Overview – History – Need - Classification –Basic steps in Additive manufacturing – Data flow– Additive Manufacturing Technology in product development– Materials for Additive Manufacturing – Applications.

Experiments: Make a prototype using FDM, Make a prototype using 3D printer

TOTAL: 75 PERIODS

8. Text Books

1. Dr. P. N Rao,"Manufacturing Technology: Foundry, Forming and Welding, 4e (Volume 1) 2013
2. Hajra Choudhury, "Elements of Workshop Technology, Vol. I and II", Media Promoters PvtLtd.,Mumbai, 2011.

9. References

1. Mikell P Groover "Fundamentals of Modern Manufacturing: Materials, Processes, and Systems", Wiley., 2015 , 6
2. Arora R P "Manufacturing Technology", Macmillan India Limited., New Delhi, 2011
3. Jain R K "Production Technology", Khanna Publishers., 2004
4. HMT "Production Technology", Tata McGraw-Hill., 2002

COURSE CODE	MACHINING AND MACHINE TOOLS	L	T	P	C
10211ME205	TECHNOLOGY	3	0	2	4

1. Preamble

Apply the knowledge on mechanics of metal cutting in conventional, special machines tools, NC, CNC Machines.

2. Pre-requisite

10211ME204 - Manufacturing Technology

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the fundamental knowledge of mechanics of metal cutting, and knowledge to operate the centre & special purpose lathes, shaper, milling, gear hobbing, and surface grinding machines.
- Understand the working principles of NC & CNC machine tools, and knowledge to operate CNC machines using G codes and M codes.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describe the mechanism of material removal process of cutting tool, and demonstrate the turning operation on the given rod using lathe machine.	K3
CO2	Explain the working principles and demonstrate the machining operation on the given workpiece using centre & special purpose lathes.	K3
CO3	Differentiate the working principles of reciprocating machines, milling, drilling & gear cutting processes.	K4
CO4	Illustrate and demonstrate the working process of grinding & superfinishing processes for the given tolerance using a surface grinding machine.	K3
CO5	Develop part program for the given drawing using G and M codes and execute the part program using CNC lathe and milling machine.	K4

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M		L	L				M	L			M	
CO2	M	M			L				M	L			M	
CO3	M	M			L				M	L			M	
CO4	M	M			L				M	L			M	
CO5	H	H	H	M	H	M			M	H		H	M	H

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I MECHANICS OF METAL CUTTING

L-9P-3

Introduction: material removal processes, types of machine tools– cutting tool geometry – Mechanics of chip formation – types of chips – cutting tool materials, tool wear, tool life, cutting fluids.

Experiments: Measurement of shear angle and cutting force during metal cutting operation in a lathe.

UNIT II CENTRE LATHE AND SPECIAL PURPOSE LATHES

L-9P-9

Centre lathe – constructional features, various operations – taper turning methods – thread cutting methods – Capstan and turret lathes – turret Indexing mechanism, bar feed mechanism, Tool Layout

Experiments: Taper turning using compound rest in a Lathe, Thread cutting operation in a Lathe, Machining of parts using Capstan lathe/ semi-automatic lathe, Machining of pin and bush.

UNIT III RECIPROCATING MACHINES, MILLING, DRILLING & GEAR CUTTING

L-9P-9

Reciprocating machine tools: Shaper – Types and operations, quick return mechanism – slotter – Milling: Up & down milling, Types of milling cutters and operations – Hole making: drilling, reaming, boring, tapping – Gear cutting: gear planning, gear shaping and gear hobbing

Experiments: Machining MS round into Square / Hexagonal using Shaper, Milling of gears on the MS round, Gear Hobbing.

UNIT IV ABRASIVE PROCESSES

L-9P-3

Abrasive processes: grinding wheel – specifications and selection, types of grinding process – cylindrical grinding, surface grinding, centerless grinding – honing – lapping – super finishing: polishing and buffing.

Experiments: Surface Grinding on MS flat.

UNIT V CNC MACHINE TOOLS

L-9P-6

Numerical Control (NC) machine tools – CNC types, constructional details, special features, machining centre – part programming fundamentals – manual part programming – computer assisted part programming – Turning and Milling

Experiments: write and execute the program for taper turning using canned cycle, write and execute the program for contour milling

TOTAL: 75 PERIODS

8. Text Books

1. Rao. P.N “Manufacturing Technology - Metal Cutting and Machine Tools”, Tata McGraw-Hill, New Delhi, 2013.
2. Kalpakjian ,”Manufacturing Processes for Engineering Materials”, Pearson education India,1992
3. Mikell P. Groover “Fundamentals of Modern Manufacturing: Materials, Processes, and Systems”, 2012.

9. References

1. HMT – “Production Technology”, Tata McGraw-Hill, 2010.
2. Philip F.Ostwald and Jairo Munoz, ‘Manufacturing Processes and systems’,

John Wiley and Sons, 10th Edition, 2012.

3. M.P.Groover and Zimmers Jr., 'CAD/CAM' Prentice Hall of India Ltd., 2011.
4. Milton C.Shaw,"Metal Cutting Principles", Oxford University Press, Third Edition, 2012.

COURSE CODE	MATERIALS AND METALLURGY	L	T	P	C
10211ME103		3	0	0	3

1. Preamble

This course imparts the knowledge on the structure, properties, heat treatment and mechanical property evaluation of ferrous and nonferrous metals so as to select the appropriate material for suitable applications.

2. Pre-requisite

10210PH103 - Applied Physics

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Gain knowledge in properties of solids.
- Acquire the knowledge about various phase diagrams of ferrous and non-ferrous metals.
- Attain knowledge in heat treatment of steels, properties of non-ferrous alloys and evaluate the mechanical properties of different metals.
- Impart the knowledge about the failure mechanism of ductile and brittle materials.
- Introduce to the processing, properties and applications of emerging engineering materials.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Illustrate the different types of crystallographic structures and crystal imperfection in solids	K3
CO2	Draw phase diagram, Iron-Iron carbon diagram of materials, and classify steel and its application in engineering field.	K3
CO3	Describe the different heat treatment and surface hardening processes for various materials.	K2
CO4	Distinguish different strengthening mechanisms, fractures and various tests to find mechanical properties of the given material.	K2
CO5	Explain the processing, properties and applications of emerging engineering materials.	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H											L	L	
CO2	H											L	L	
CO3	H											L	L	
CO4	H											L	L	
CO5	H											L	L	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I STRUCTURE OF MATERIALS

L-9

Introduction to Engineering Materials – Classification of Materials - Engineering properties of materials - Metallic Crystal Structures, Crystal Systems, Crystallographic Directions, Crystallographic Planes, Significance of Structure Property Correlations in Engineering Materials, Linear and Planar Densities, Crystalline and Non-crystalline Materials, Single Crystals, Polycrystalline Materials, Imperfection in Solids – Point, Line, Surface and Volume defects.

UNIT II PHASE DIAGRAMS AND CONSTITUTION OF ALLOYS

L-9

Introduction to Solid Solutions - Phase Rules and its Application - Construction of Phase Diagrams - Classification of Phase Diagram - Equilibrium Diagram of Iron and Iron–Carbide Diagram - Introduction to TTT & CCT Diagrams, Construction and its Importance. Steels – Types of Steels - Cast Irons – Types of Cast Irons - Effect of Alloying Elements on Structure and Properties of Steels – Types of Stainless Steels. Properties and Applications of Aluminum, Copper, Titanium and their alloys.

UNIT III HEAT TREATMENT AND SURFACE HARDENING

L-9

Heat Treatment – Overview – Objectives – Annealing and Types, Normalizing, Quenching, Austempering and Martempering – Effect on Hardness and Microstructure. Surface Hardening Processes - Carburizing – Nitriding – Cyaniding and Carbonitriding, Induction and Flame hardening, Laser and Electron Beam Hardening– Principles and Case Depths – Vacuum and Plasma Hardening.

UNIT IV MECHANICAL BEHAVIOUR OF MATERIALS

L-9

Strengthening Mechanisms – Introduction to Micro and Nanoindentation Tests – Hardenability – Fracture of Metals – Ductile Fracture, Brittle Fracture, Griffith's Theory - Fatigue – Fatigue Test, S-N Curves, Factors affecting Fatigue - Creep and Stress Rupture – Mechanism of Creep – Stages of Creep and Creep Test – Introduction to Fracture Mechanics – Fracture Toughness Tests.

UNIT V ADVANCED ENGINEERING MATERIALS

L-9

Ceramics – Properties and Applications of Various Ceramics (SiC, WC, TiC, Al₂O₃,) - Composites – Matrix and Reinforcement Materials – Applications of Composites - Introduction to Smart Materials and its types : Processing of Shape Memory Alloys, Properties and Applications - Processing of Metallic Glasses, Properties and Applications - Introduction to Quasi Crystals, Properties and Applications - Concept of Nano Crystalline Materials, Properties and Applications – Processing of Piezoelectric Materials, Properties and Applications.

TOTAL: 45 PERIODS

8. Text Books

1. W.D. Callister, David G. Rethwisch, "Materials Science and Engineering: An Introduction", 9th ed., Wiley & Sons, 2013.
2. Thomas H. Courtney, "Mechanical Behaviour of Engineering materials", McGraw Hill, Singapore, 2000.
3. Kenneth G. Budinski and Michael K. Budinski, "Engineering Materials", Prentice Hall of India Private Ltd, 4th Indian Reprint 2002.

9. References

1. Donald R. Askeland, Pradeep P. Fulay, Wendelin J. Wright, "The Science and Engineering of Materials", 6th Edition, Cengage Publications, 2010.
2. Flake. C Campbell, "Elements of Metallurgy and Engineering Alloys", ASM International, 2008.
3. Dieter .G. E, "Mechanical Metallurgy", McGraw Hill, Singapore, 2001.
4. Sidney H. Avner, "Introduction to Physical Metallurgy", Tata Mcgraw Hill

COURSE CODE	MEASUREMENTS AND CONTROL	L	T	P	C
10211ME206		2	0	2	3

1. Preamble

This course provides knowledge on various metrological equipment's available to measure the Dimensions of the components and to understand the principles of Laser and advances in metrology.

2. Pre-requisite

10210PH103 - Applied Physics

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the significance of measurement, generalized measurement system.
- Have familiarity on the correct procedure to be adopted to measure the dimension of the Components
- Select the suitable techniques for form measurements in industrial applications
- Understand the principles of laser and advances in metrology
- Select the equipment and suitable technique to measure the power and temperature.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describe the importance, standards, and functions of measurement instruments.	K2
CO2	Choose suitable measuring instruments for linear and angular measurements for engineering applications.	K3
CO3	Choose suitable form measurement technique to measure the dimensions of the given screw and gear tooth.	K4
CO4	Apply laser and advanced instruments to measure the straightness, flatness, and angularity of given engineering components.	K4
CO5	Choose and apply suitable measurement techniques to measure the power and temperature of given applications.	K4

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	H							M	L			M	
CO2	L	H							M	L			M	
CO3	L	H							M	L			M	
CO4	L	H		L	L				M	L		L	M	
CO5	L	H		L	L				M	L			M	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I CONCEPT OF MEASUREMENT

L-6 P-6

General concept – Generalized measurement system-Units and standards-measuring instruments sensitivity, readability, range of accuracy, precision-static and dynamic response-repeatability systematic and random errors-correction, calibration, interchangeability.

Experiments: Demonstration on various measuring instruments of concept of measurement.

UNIT II LINEAR AND ANGULAR MEASUREMENT

L-6 P-6

Linear measuring instruments: Vernier, micrometer, Slip gauges, limit gauges-Comparators: Mechanical, pneumatic and electrical. Angular measurements: -Sine bar, optical bevel protractor.

Experiments: Calibration of linear measuring instruments, Calibration of angle measuring Instruments.

UNIT III FORM MEASUREMENT

L-6 P-6

Measurement of screw threads-Thread gauges-measurement of gears-tooth thickness-constant chord and base tangent method –surface finish, straightness and flatness measurements,

Experiments: Measurement of thread parameters, Measurements of Gear Tooth Dimensions.

UNIT IV LASER AND ADVANCES IN METROLOGY

L-6 P-6

Precision instruments based on laser-Principles- laser interferometer-application in linear, angular Measurements and machine tool metrology, Coordinate measuring machine (CMM) – Constructional Features – types, applications, Basic concepts of Machine Vision System – Element – Applications.

Experiments: Measurement of the taper angle used by profile projector, Measurement of Straightness and flatness used by Autocollimator.

UNIT V MEASUREMENT OF POWER AND TEMPERATURE RELATED PARAMETER

L-6 P-6

Measurement of power: mechanical, pneumatic, hydraulic and electrical type. Temperature: Bimetallic strip, pressure thermometers, thermocouples.

Experiments: Measurement of Displacement, Temperature, Force and torque.

TOTAL: 60 PERIODS

8. Text Books

1. Jain. R.K., "Engineering Metrology", Khanna Publishers, New Delhi, 2009.
2. Dr N. V. Raghavendra, Dr L. Krishnamurthy., "Engineering Metrology and Measurements", OUP India Publishers, 2013.

9. References

1. Thomas G.Beckwith, RoyD.Marangoni, JohnH.Lienhard V, "Mechanical Measurements",Pearson Education, 2007.
2. Alan S. Morris, "The Essence of Measurement", Prentice Hall of India, 1997
3. A.K, "Instrumentation and Mechanical Measurements", Galgotia Publications, 2005
4. A.M.Badadhe, "Metrology and Quality Control", Technical Publications, Pune, 2006.

COURSE CODE	MECHATRONICS	L	T	P	C
10211ME207		3	0	2	4

1. Preamble

This course provides an introduction to the multidisciplinary field of engineering, modeling of Mechatronics systems; microprocessor programming and interfacing; architecture of PLC; selection and implementation of sensors and actuators; and case studies in Mechatronics systems.

2. Pre-requisite

10210EE201 – Basic Electrical, Electronics and Measurements Engineering

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Knowledge in mechanical, electronics and computing Engineering.
- The terminologies of microprocessor programming, understand the principles of Sensors, Actuators and Control systems.
- The knowledge to design solutions for the Mechatronics systems.
- The knowledge in applying real time applications.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Choose and design key components of mechatronic systems for Washing machine control and Water heater application.	K3
CO2	Explain and demonstrate the Architecture, PinDiagram, and addressing modes of the Microprocessor and Microcontroller.	K3
CO3	Demonstrate Stepper Motor Interfacing with 8051 Microcontroller.	K3
CO4	Model and Analyze simple mechatronics systems and Demonstrate data logging system to control pressure, flow and temperature using SACADA software.	K4
CO5	Simulate Hydraulic, Pneumatic and Electric circuits for given applications using automation studio software.	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	L										H	
CO2	H	H	L										H	
CO3	H	H	L		L				L	L			H	H
CO4	H	H	L		L		L		L	L		L	H	H
CO5	H	H	L		L		L		L	L	L	L	H	H

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION TO MECHATRONICS SYSTEMS

L-9 P-6

Introduction to Mechatronics systems, Mechatronics system components - Measurement Systems, Control Systems - Open and Closed Loops Systems with examples – Water level controller, Shaft speed control, Sequential Controllers with examples - Washing machine control, Water heater, Advanced approaches in Mechatronics - Industrial design and ergonomics, safety.

Experiments: Design of circuits with logic sequence using Electro pneumatic trainer kits.

UNIT II MICROPROCESSOR IN MECHATRONICS

L-9 P-6

Microprocessors and Microcontrollers, Architecture of 8085, Pin diagram of 8085, Instruction set – Addressing modes – I/O Programming-Timer/Counter - Interrupts – Serial communication of 8055, Introduction to embedded systems.

Experiments: Circuits with multiple cylinder sequences in electro pneumatic using PLC.

UNIT III ELECTRICAL DRIVES AND PLC

L-9P-6

Electrical drives - stepper motors and servo motors and Linear motors. Fundamentals of programmable logic controller – Functions of PLCs, PLC operations, Evaluation of the modern PLC, Memory, Selection of PLC, Features of PLC, Architecture, Basics of PLC programming, Developing Fundamental wiring diagrams, Problem solving using logic ladder diagrams, communication in PLCs, Programming Timers, Programming counters, Data Handling.

Experiments: Stepper Motor Interfacing with 8051 Micro controller - Full step resolution and half step resolution, Speed control of servo motor, Circuits with multiple cylinder sequences in Electro pneumatic using PLC.

UNIT IV SENSORS

L-9 P-6

Basics of Measurement, Classification of errors, Error analysis, Classification of sensors, Motion Sensors – Brush Encoders, Potentiometers, Encoders – Optical, Magnetic, Inductive, Capacitive, LVDT, Strain Gage, Load Cell Magnetic Sensors, Pressure and Temperature sensors - types, principles

Experiments: Computerized data logging system with control for process variables like pressure, flow and temperature, Modeling and analysis of basic systems using LAB VIEW.

UNIT V MECHATRONICS SYSTEM DESIGN AND APPLICATION L-9P-6

Stages in designing Mechatronics Systems – Traditional and Mechatronics Design - Case Studies of Mechatronics Systems –Pick and place robot – Automatic car park systems –Wind screen wiper motion – Autofocus Camera, Controlling temperature of a hot/cold reservoir using PID, ABS.

Experiments: Simulation of basic Hydraulic, Pneumatic and Electric circuits using automation studio software.

TOTAL: 75 PERIODS

8. Text Books

1. W.Bolton, Electronic Control Systems in Mechanical and Electrical Engineering, Prentice Hall, New Delhi, 2003.
2. James Harter, Electromechanics, Principles and Concepts and Devices, Prentice Hall, New Delhi, 2003.

9. References

1. David W. Pessen, Industrial Automation Circuit Design and Components, John Wiley, New York, 1990.
2. Rohner, P., Automation with Programmable Logic Controllers, Macmillan / McGraw Hill, New York, 1996.
3. Brian Morris, Automatic Manufacturing Systems Actuators, Controls and Sensors, McGraw Hill, New York, 1994.
4. Goankar, R. S., Microprocessor Architecture Programming and Applications, Wiley Eastern, New Delhi, 1997.

COURSE CODE	ENGINEERING THERMODYNAMICS	L	T	P	C
10211ME104		2	2	0	3

1. Preamble

This course provides an introduction to the basic concepts in thermodynamics, first law of thermodynamics and energy, second law, entropy, enthalpy and internal energy, ideal and real gases and non-reactive ideal gas mixtures and general thermodynamic property relations and also thermal behavior of pure substance. It develops the problem solving skills in engineering problems in basic thermodynamics.

2. Pre-requisite

10210PH103 - Applied Physics

3. Link to the other courses

10211ME105 - Applied Engineering Thermodynamics

4. Course Educational Objectives

Students, after undergoing this course would

- Solve problems based on the laws and principles of thermodynamics on non-flow and flow processes.
- Comprehend the thermodynamic properties of ideal and real gases, gaseous mixtures and their relationships.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Solve open and closed system problems using thermodynamic principles and the first law of thermodynamics.	K3
CO2	Compute thermodynamic parameters of thermal devices using the second law of thermodynamics.	K3
CO3	Calculate work done and heat transfer on flow and non-flow process using steam tables and Mollier chart	K3
CO4	Examine the properties of ideal, real gas and its mixtures with its properties using physical laws and compressibility chart.	K4
CO5	Deduce the thermodynamic property relations to determine the behaviour of gases.	K4

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	L										H	L
CO2	H	H	L				M						H	L
CO3	H	H	L					H					H	L
CO4	H	H	L					M					H	L
CO5	H	H	L					L					H	L

(H- High; M-Medium; L-Low)

7. Course Content

Steam tables, Mollier charts and Psychometric charts are permitted.

UNIT I BASIC CONCEPTS AND FIRST LAW

L-6 T-6

Basic concepts, Concept of continuum, Microscopic and Macroscopic approach, Thermodynamic systems, control volume, property, point and path functions, Thermodynamic equilibrium, State and process, Reversible and Quasi-static process, Work, Zeroth law, Concept of temperature and heat. First law, Application to closed and open systems, Internal energy, Enthalpy, Steady flow process with reference to various engineering devices.

UNIT II SECOND LAW, ENTROPY AND EXERGY

L-6 T-6

Second law – Kelvin Planck and Clausius statements, Heat engine, Refrigerator and Heat pump, Efficiency and COP, Thermodynamic temperature scale, Reversibility and Irreversibility, Carnot theorem, Clausius Inequality, Concept of entropy, Entropy of ideal gases, Principle of increase of entropy, Quality of energy, Energy (Availability), Reversible work, Energy and Irreversibility for closed system and control volume, Second law efficiency.

UNIT III PROPERTIES OF PURE SUBSTANCES

L-6 T-6

Thermodynamic properties of pure substances in solid, liquid and vapour phases, P-V, P-T, T-V, T-S and H-S diagrams, PVT surfaces, Thermodynamic properties of steam, Use of steam tables and Mollier chart, Calculation of work done and heat transfer in non-flow and flow processes.

UNIT IV IDEAL & REAL GASES AND NON-REACTIVE IDEAL GAS MIXTURES

L-6 T-6

Properties of ideal and real gases, Avagadro's hypothesis and gas laws, Vander Walls and other equations of state, Principle of corresponding states, Compressibility factor, and generalized compressibility charts. Non-reactive ideal gas mixtures, Mass and Mole fractions, Dalton's law of additive pressures, Amagat's law of additive volumes, Properties of ideal gas mixtures.

UNIT V GENERAL THERMODYNAMIC PROPERTY RELATIONS

L-6 T-6

Partial derivatives and associated relations, Differential relations for U, H, G and A, Maxwell's relations, Clausius-Clapeyron equation, Joule Thomson coefficient, Air and Gas tables.

TOTAL: 60 PERIODS

8. Text Books

1. Yunus A Cengel / Michael A Boles, "Thermodynamics - An Engineering Approach" (SI Units), Tata Mc Graw Hill India, 8th Edition 2017.
2. P K Nag, "Engineering Thermodynamics", Tata McGraw Hill, New Delhi, 6th Edition, 2013.
3. R K Rajput, "Engineering Thermodynamics (SI Units)", Laxmi Publications PVT Limited, 5th Edition, 2019.

9. References

1. Yadav R, "Fundamentals of Engineering Thermodynamics", 7e, Vol 1, Central Publishing House, 2011.
2. Jones J.B and Dugan R.E., "Engineering Thermodynamics", Prentice Hall of India, 2011
3. Roy Choudry T., "Basic Engineering Thermodynamics", Second Edition, Tata McGraw Hill, 2012.

COURSE CODE	FLUID MECHANICS AND MACHINERY	L	T	P	C
10211ME208		3	0	2	4

1. Preamble

This course provides an introduction to the properties and behaviour of fluids. It introduces dimensional analysis and enables to demonstrate the concepts in civil pipe networks and channel.

2. Pre-requisite

Engineering Mathematics-I

3. Link to the other courses

10211ME210 - Heat and Mass Transfer

Applied Hydraulics and Pneumatics

Computational Fluid Dynamics

4. Course Educational Objectives

Students, after undergoing this course would

- Apply fundamental knowledge of mathematics and science to modelling and analysis of fluid flow problems in civil and environmental engineering.
- Illustrate the experiments in pipe flows and open-channel flows and interpreting data from model studies to prototype cases, as well as documenting them in engineering reports.
- Recognize the awareness of disasters caused by an incorrect analysis in hydraulic engineering system.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describe the physical properties of compressible and incompressible fluid flow and calculate the hydrostatic pressure and force on the plane and curved surfaces using manometers and pressure gauges.	K3
CO2	Determine the coefficient of discharge of the given Orifice meter, Venturimeter, and Pitot tube using Bernoulli's principle.	K3
CO3	Evaluate pressure drop using Hagen-Poiseuille's equation and examine energy losses in pipe transitions for laminar flow using Darcy -weisback's equation.	K4
CO4	Draw and Analyze the performance characteristic curves of Pelton Wheel, Francis turbine and Kaplan turbine for the given condition	K4
CO5	Draw and Analyze the performance characteristic curves of gear pump and submersible pump for the given condition	K4

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H								L			H	L
CO2	H	H	L							L			H	L
CO3	H	H	L	M						L			H	L
CO4	H	H	L	M						L			H	L
CO5	H	H	L	M						L			H	L

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I BASIC CONCEPTS AND PROPERTIES

L-9 P-6

Fluid – definition, distinction between solid and fluid - Units and dimensions - Properties of fluids - Densities, specific weight, specific volume, specific gravity, temperature, viscosity, compressibility, vapor Pressure, capillary and surface tension - Fluid statics: concept of fluid static pressure, absolute and gauge pressures - pressure measurements by manometers and pressure gauges.

Experiments: Pressure measurements by manometers and pressure gauges.

UNIT II FLUID KINEMATICS AND BOUNDARY LAYER CONCEPTS

L-9 P-6

Fluid Kinematics - Flow visualization - lines of flow - types of flow (uniform flow and non-uniform flow)-Continuity equation (one dimensional differential forms) - fluid dynamics - equations of motion – Navier- Stokes's equation (Statement only) Euler's equation along a streamline - Bernoulli's equation – applications - Venturi meter, Orifice meter, Pitot tube - Boundary layer flows, boundary layer thickness, Boundary layer separations - drag and lift coefficients.

Experiments: Determine the Coefficient of discharge of given Orifice meter / Venturimeter and Pitot tube.

UNIT III FLOW THROUGH PIPES AND DIMENSIONAL ANALYSIS

L-9 P-6

Viscous flow - Shear stress, pressure gradient relationship - laminar flow between parallel plates - Laminar flow through circular tubes (Hagen poiseuille's) - Hydraulic and energy gradient - flow through pipes - Darcy -weisback's equation - pipe roughness -friction factor-minor losses - flow through pipes in series and in parallel - power transmission - Dimensional analysis - Buckingham's theorem applications-similarity laws and models.

Experiments: Determine the Friction Factor of fluid flow by Major loss / Minor loss. Determine the rate of flow using Rotameter, Experimental Verification of Bernoulli's theorem.

UNIT IV HYDRAULIC TURBINES

L-9 P-6

Hydro turbines: definition and classifications - Pelton turbine - Francis turbine - Kaplan turbine - working principles - velocity triangles - work done - specific speed - efficiencies -performance curve for turbines.

Experiments: Conduct experiment and draw the performance characteristic curves of Pelton Wheel Turbine, Francis turbine and Kaplan turbine.

UNIT V HYDRAULIC PUMPS

L-9 P-6

Pumps- classifications - Centrifugal pump- classifications, working principles, priming, velocity triangles, specific speed, efficiency and performance curves - Reciprocating pump- classification, working principles, slip, performance curves and work saved by air vessels - cavitations in pumps – working Principles of gear pump and submersible pump.

Experiments: Conduct experiment and draw the performance characteristic curves of Gear Pump /Jet Pump and Submersible Pump.

TOTAL: 75 PERIODS

8. Text Books

1. Modi P.N. and Seth, S.M. "Hydraulics and Fluid Mechanics", Standard Book House, New Delhi 22nd edition 2019.
2. Streeter, V. L. and Wylie E. B., "Fluid Mechanics", McGraw Hill Publishing Co. 9th edition 2017.

9. References

1. Kumar K. L., "Engineering Fluid Mechanics", S.Chand & Company Pvt. Ltd, 2014.
2. Robert W. Fox, Alan T. McDonald, Philip J. Pritchard, "Fluid Mechanics and Machinery", 2019.
3. Graebel. W.P, "Engineering Fluid Mechanics", Taylor & Francis, Indian Reprint, 2018.
4. Bansal, R.K., "Fluid Mechanics and Hydraulics Machines", (Revised 10th edition), Laxmi publications (P) Ltd., New Delhi, 2019.

COURSE CODE	APPLIED ENGINEERING	L	T	P	C
10211ME105	THERMODYNAMICS	2	2	0	3

1. Preamble

This course provides an update to the knowledge base of the students in Thermodynamics. Students gain knowledge on application of thermodynamic principles on thermodynamic cycles and devices. The students will also learn upon the behaviour of pure substance on thermal environment and methods to recover heat.

2. Pre-requisite

10211ME104 - Engineering Thermodynamics

3. Link to the other courses

10211ME209 - Thermal Engineering

10211ME210 - Heat and Mass Transfer

Refrigeration and Air-Conditioning

4. Course Educational Objectives

Students, after undergoing this course would

- Comprehend the operating principles of gas, vapour and refrigerant cycles involved in power generators and methods of heat recovery.
- Understand the working principles and performance characteristics of refrigerators and air conditioners.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Compare the performance of simple vapour cycle with its modifications and Estimate the thermal behaviour of binary and combined cycles.	K4
CO2	Estimate the air standard efficiency and mean effective pressure of vapour power cycles.	K3
CO3	Differentiate the working principle of refrigeration systems and analyze the performance of refrigeration systems	K4
CO4	Calculate the properties of air vapour mixture for the given condition using Psychrometric charts.	K3
CO5	Examine the performance and economic analysis of cogeneration systems and its components.	K4

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	L									L	H	L
CO2	H	H										L	H	L
CO3	H	H	L					L				L	H	L
CO4	H	H					L					L	H	L
CO5	H	H	L				L	L			L	L	H	L

(H- High; M-Medium; L-Low)

7. Course Content

Use of steam tables, Refrigerant table and psychometric charts are permitted

UNIT I VAPOUR POWER CYCLES

L-6 T-6

Rankine cycle modified Rankine cycle, Reheating and Regeneration cycles, Binary vapour cycle, combined gas-vapour power cycles.

UNIT II GAS POWER CYCLES

L-6 T-6

Otto cycle, Diesel cycle and Dual cycles, Air standard efficiency, mean effective pressure, Comparison of Otto, Diesel and Dual cycles, Ideal and Actual Brayton cycle, Stirling cycle, Ericsson cycle, Atkinson cycle.

UNIT III REFRIGERATION SYSTEMS

L-6 T-6

Refrigerants – types, Desirable properties and environmental effects, Air refrigeration cycle, Vapour Compression Refrigeration cycle, Sub cooling and Super heating, Performance calculations, Vapour Absorption Refrigeration – Ammonia water, Lithium Bromide water systems (Description only), Comparison between Vapour Compression and Vapour Absorption Refrigeration systems.

UNIT IV PSYCHROMETRY AND AIR – CONDITIONING

L-6 T-6

Psychrometric properties, Use of psychometric chart, Psychrometric processes – Sensible heat Exchange process, Latent heat exchange process, Adiabatic mixing, Evaporative cooling, Property Calculations of air-vapour mixtures. Principles of air-conditioning, Types of air conditioning systems – summer, winter, and year round air conditioners.

UNIT V COGENERATION AND RESIDUAL HEAT RECOVERY

L-6 T-6

Cogeneration Principles, Cycle Analysis, Applications, Source and utilization of residual heat. Heat pipes, Heat pumps, Recuperative and Regenerative heat exchangers. Economic Aspects.

TOTAL: 60 PERIODS

8. Text Books

1. Yunus A Cengel / Michael A Boles, "Thermodynamics - An Engineering Approach", (SI Units), McGraw-Hill Higher Education, Eighth Edition, 2017.
2. R K Rajput, "Engineering Thermodynamics (SI Units)", Laxmi Publications PVT Limited, 5th Edition, 2019.
3. P K Nag, "Basic and Applied Thermodynamics", Tata Mc Graw Hill, New Delhi, 2014.
4. C. P. Arora and Domkundwar, "A Course in Refrigeration and Air-Conditioning", Dhanpat Rai & Sons, 2014.

9. References

1. Onkar Singh, "Applied Thermodynamics", New Age International (Pvt) Limited Publishers, Third Edition, 2014.
2. Dr. R. Yadav, Applied Thermodynamics, (SI Units), Central Publishing House, 6th Revised Edition 2013.
3. Jones J.B and Dugan R.E., "Engineering Thermodynamics", Prentice Hall of India, 2014.
4. TD Eastop, A Mc Conkey, "Applied Thermodynamics For Engineering Technologists", Pearson Education Ltd., 2014.

COURSE CODE	THERMAL ENGINEERING	L	T	P	C
10211ME209		3	0	2	4

1. Preamble

This course imparts understanding about the power generation using heat energy conversion and makes an attempt to be conversant with the equipment used in the process. It helps in understanding the thermodynamic concepts, the construction and the working principles of various engineering devices such as steam generators, steam nozzles, steam turbine, internal combustion engines and gas turbines.

2. Pre-requisite

10211ME105 - Applied Engineering Thermodynamics

3. Link to the other courses

Power Plant Engineering
Automobile Engineering

4. Course Educational Objectives

Students, after undergoing this course would

- To understand the concepts associated with the construction and to demonstrate the working principles of various thermal devices such as steam generators, steam nozzles, steam turbines, I.C. engines and gas turbines.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Analyze the performance of boilers and assess the thermal behaviour under the given load.	K4
CO2	Examine the efficiency and process parameters of nozzles and turbines for the given specifications.	K4
CO3	Demonstrate the working principle of IC Engines and its components and accessories.	K4
CO4	Test the Engines to determine the process parameters for the given loads and conditions. Determine the optimum pressure ratio and efficiency of gas turbines.	K3
CO5	Calculate the Efficiency of rotary and reciprocating air compressors for the given condition.	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H				L				L			M	L
CO2	H	H								L			M	L
CO3	H	H								L			M	L
CO4	H	H		M		L	L			L			M	L
CO5	H	H								L			M	L

(H- High; M-Medium; L-Low)

7. Course Content

Steam tables, Mollier charts and psychometric charts are required.

UNIT I STEAM GENERATORS

L-9 P-6

Types and classification- low pressure fire & water tube boilers-mountings & accessories-performance Testing of boilers-equivalent evaporation-boiler efficiency-boiler trial & Heat balance sheet – criteria for Selection of a boiler. High pressure boilers introduction.

Experiments: Performance test on boiler.

UNIT II STEAM NOZZLES AND TURBINES

L-9 P-6

Expansion of steam through nozzle-types of nozzles-condition for maximum discharge- critical pressure Ratio- effect of friction – super saturated flow – steam jet pump. Principles of impulse, reaction and impulse-reaction turbines-compounding-velocity diagrams for simple & multistage turbines-work done on turbine blades & efficiencies-losses in steam turbines governing of steam turbines.

Experiments: Performance analysis of Steam turbine.

UNIT III INTERNAL COMBUSTION ENGINES AND COMBUSTION

L-9 P-6

IC engine – Classification, working, components and their functions. Ideal and actual : Valve and port timing diagrams, p-v diagrams- two stroke & four stroke, and SI & CI engines – comparison. Geometric, operating, and performance comparison of SI and CI engines. Desirable properties and qualities of fuels. Air-fuel ratio calculation – lean and rich mixtures. Combustion in SI & CI Engines – Knocking – phenomena and control.

Experiments: Port and valve timing diagrams of petrol and diesel engines.

UNIT IV INTERNAL COMBUSTION ENGINE PERFORMANCE AND GAS TURBINES

L-9 P-6

Performance parameters and calculations. Morse and Heat Balance tests - injection and Ignition systems –Lubrication and Cooling systems. Concepts of Supercharging and Turbocharging –Emission norms.

Experiments: Performance Test and Heat Balance Tests on 4 stroke IC engines.

UNIT V RECIPROCATING AIR COMPRESSORS

L-9 P-6

Classification and comparison, working principle, work of compression - with and without clearance, volumetric efficiency, Isothermal efficiency and isentropic efficiency. Multistage air compressor with Intercooling. Working principle and comparison of Rotary compressors with reciprocating air Compressors.

Experiments: Testing on single and multi-stage air compressors.

TOTAL: 75 PERIODS

8. Text Books

1. 1. Nag. P.K., Engineering Thermodynamics", Tata McGraw Hill, Fourth Edition, 2018
2. 2. Domkundwar, A., A Course in Thermal Engineering", Dhanpat Rai & Co., New Delhi, 2013
3. 3. V. Ganesan, Internal Combustion Engines", Tata McGraw Hill, Fourth Edition, 2017

9. References

1. 1. Rajput, R. K. "Thermal Engineering", Laxmi Publications, New Delhi, 11th Edition, 2020.
2. 2. J.B Heywood, "I.C engines fundamentals", McGraw Hill International Edition. 2nd Edition 2018.
3. 3. P.W Gill. J.H Smith & E.J Ziurgs, " Fundamentals of I.C Engines", Oxford & I B H Publication, 2007, New Delhi.
4. 4. R. YADAV, "Steam & Gas Turbines", Central Publishing House, 7th Revised Edition.
5. 5. P.L Ballaney, "Thermal Engineering, Khanna Publication, 5th Edition.

COURSE CODE	HEAT AND MASS TRANSFER	L	T	P	C
10211ME210		3	0	2	4

1. Preamble

This course deals with the different modes of heat transfer from one medium to another. It enables an understanding of the laws governing the heat transfer and mass transfer processes and helps in designing various thermal equipment's.

2. Pre-requisite

10211ME105 - Applied Engineering Thermodynamics

3. Link to the other courses

PowerPlantEngineering

AutomobileEngineering

ComputationalFluidDynamics

4. Course Educational Objectives

Students, after undergoing this course would

- To understand the modes of heat transfer and their applications
- To apply the various methods on heat and mass transfer & their applications.
- To find the behaviour of fluids in various modes of heat and mass transfer
- To design and identify various types of heat exchangers for different thermal applications.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Find thermal properties based on steady and unsteady state conduction heat transfer for the given condition.	K3
CO2	Demonstrate, compare and contrast the natural and forced convection heat transfer for the given condition	K3
CO3	Design and analyze parallel and counter flow arrangements for the given condition.	K4
CO4	Analyze the effect of radiation heat transfer on grey bodies and compare with the black and white bodies.	K4
CO5	Compare heat and mass transfer and compute diffusion and convective mass transfer for given condition.	K4

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H								M			H	L
CO2	H	H	L							M			H	L
CO3	H	H	L							M			H	L
CO4	H	H	L			L	L			M			H	L
CO5	H	H	L				L			M			H	L

(H- High; M-Medium; L-Low)

7. Course Content

HMT Data book is permitted

UNIT I CONDUCTION

L-9 P-6

Basic Concepts – Mechanism of Heat Transfer – Conduction, Convection and Radiation – General Differential equation of Heat Conduction – Fourier Law of Conduction – Cartesian and Cylindrical Coordinates – One Dimensional Steady State Heat Conduction – Conduction through Plane Wall, Cylinders and Spherical systems – Composite Systems – Conduction with Internal Heat Generation – Extended Surfaces – Unsteady Heat Conduction – Lumped Analysis – Infinite and Semi Infinite Solids - Analysis using Heisler chart – Introduction to 2-D heat transfer

Experiments: Determination of thermal conductivity using thermal testing apparatus.

UNIT II CONVECTION

L-9 P-6

Basic Concepts – Convective Heat Transfer Coefficients – Boundary Layer Concept – Forced Convection– External Flow – Flow over Plates, Cylinders Spheres and Bank of tubes – Internal Flow – Free Convection – Flow over Vertical Plate, Horizontal Plate, Inclined Plate, Cylinders and Spheres, Nusselt's Theory of condensation - Regimes of pool boiling and flow boiling, Correlations in boiling and Condensation.

Experiments: Determination of heat transfer coefficient in natural and forced convection setup.

UNIT III PHASE CHANGE HEAT TRANSFER AND HEAT EXCHANGERS

L-9 P-6

Nusselt's theory of condensation - Regimes of Pool boiling and Flow boiling. Correlations in boiling and condensation. Heat Exchanger Types - Overall Heat Transfer Coefficient – Fouling Factors – Analysis –LMTD Method- NTU Method.

Experiments: Comparison of parallel flow and counter flow heat exchanger.

UNIT IV RADIATION

L-9 P-6

Basic Concepts, Laws of Radiation – Wien's Displacement Law - Stefan Boltzmann Law, Kirchhoff Law –Black Body Radiation – Grey body radiation - Shape Factor – Electrical Analogy – Radiation Shields.

Experiments: Comparison of radiation heat transfer between different bodies.

UNIT V MASS TRANSFER

L-9 P-6

Basic Concepts – Diffusion Mass Transfer – Fick's Law of Diffusion – Introduction to Steady state Molecular Diffusion – Convective Mass Transfer – Momentum, Heat and Mass Transfer Analogy – Convective Mass Transfer Correlations (Concept only).

Experiments: Experiment on mass transfer diffusion coefficient.

TOTAL: 75 PERIODS

8. Text Books

1. Holman, J.P., Heat and Mass Transfer, 10e, McGraw Hill, 2011.
2. Sachdeva, R.C., Fundamentals of Heat and Mass Transfer, Fourth Edition, New Age International (P) Ltd., New Delhi, 2012

9. References

1. Yunus A. Cengel, Heat Transfer A Practical Approach – Tata McGraw Hill - 5e, 2015.
2. Frank P. Incropera and David P. Dewitt, Fundamentals of Heat and Mass Transfer, John Wiley & Sons, Seventh Edition, 2013.
3. Nag, P.K., Heat Transfer, Tata McGraw Hill, New Delhi, 3e, 2011.
4. Ozisik, M.N., Heat Transfer, McGraw Hill Book Co., 2003.
5. Kothadaraman, C. P., Fundamentals of Heat and Mass Transfer, Fifth Edition, New Age International (P) Ltd., New Delhi, 4e, 2012
6. Incropera F.P., DeWitt D. P., "Fundamentals of Heat Transfer", 6th edition 2011

COURSE CODE	SOFT COMPUTING FOR MECHANICAL ENGINEERS	L	T	P	C
10211ME106		3	0	0	3

1. Preamble

This course will cover fundamental concepts of Artificial Neural Networks (ANNs), and optimization techniques such as Genetic Algorithm (GA). It will endow students with abilities in designing and implementing soft computing-based solutions for real-world and engineering problems.

2. Pre-requisite

NIL

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- To identify and describe soft computing techniques and their roles in building intelligent machines.
- To recognize the feasibility of applying a soft computing methodology for a particular problem.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describe and compare the features of hard, soft, and hybrid computing	K3
CO2	Apply artificial neural network technique to validate the given problem.	K4
CO3	Test single and multi-objective optimization for the given problem.	K3
CO4	Apply and solve real-time engineering applications using Genetic algorithm.	K3
CO5	Compare the working principle of Particle Swarm, Genetic, and Ant Colony optimization techniques.	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

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

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION

L-9

Introduction - Hard Computing - Features of Hard Computing - Examples of Hard Computing; Soft Computing - Features of Soft Computing - Examples of Soft Computing; Hybrid Computing - Examples of Hybrid Computing.

UNIT II ARTIFICIAL NEURAL NETWORKS

L-9

Overview of Artificial Neural Networks (ANN) - Models of a neuron - Network architectures - Bayes theorem - Naïve Bayes classifier - Rosenblatt's Perceptron - Perceptron convergence theorem - Multilayer Perceptron - Back propagation - Application of ANN in Classification and Regression - Classifier performance measures - Validation techniques.

UNIT III OPTIMIZATION: FUNDAMENTALS

L-9

General Characteristics of mechanical elements, adequate and optimum design, principles of optimization, formulation of objective function, design constraints – Classification of optimization problem. Single variable and multivariable optimization, Techniques of unconstrained minimization, Single objective and multi-objective optimization.

UNIT IV GENETIC ALGORITHMS

L-9

Fundamentals of Genetic Algorithms - Creation of offspring – Encoding - Fitness function - Reproduction - Inheritance operators – Crossover - Inversion and deletion – Mutation - Generational cycle - Convergence of GA - Applications.

UNIT V APPLIED SOFT COMPUTING

L-9

Simulated Annealing - Working Principle; Particle Swarm Optimization - Working Principle - Comparisons between PSO and GA; Ant Colony optimization - Working Principle.

TOTAL: 45 PERIODS

8. Text Books

1. Pratihari, Dilip Kumar. Soft computing. Alpha Science International, Ltd, 2007.
2. Sivanandam, S. N., and S. N. Deepa. Principles of soft computing (with CD). John Wiley & Sons, 2007.

9. References

1. Rao, Singiresu S. Engineering optimization: theory and practice. John Wiley & Sons, 2019.
2. Deb, Kalyanmoy. Optimization for engineering design: Algorithms and examples. PHI Learning Pvt. Ltd., 2012.

Program Elective

COURSE CODE	MECHANICS OF COMPOSITE MATERIALS	L	T	P	C
10212ME101		3	0	0	3

1. Preamble

The course provides a basic introduction to composite materials and mechanics aspects of it in an attempt to find its response to loading.

2. Pre-requisite

10211ME101-Engineering Mechanics
10211ME202-Strength of Materials

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the need of composites in structural and non-structural applications.
- Know the properties and application of different types of reinforcements and matrices.
- Understand the concepts of micro and macro mechanics of lamina.
- Analyze the macro mechanical behaviors of laminate.
-

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Distinguish different types of composite materials and their applications.	K3
CO2	Apply constitutive equations of composite materials and understand mechanical behavior at macro levels	K3
CO3	Apply constitutive equations of composite materials and understand mechanical behavior at micro levels	K3
CO4	Discuss the relations and steps in the macro mechanics of laminate	K2
CO5	Identify strength and failure of lamina and laminates under mechanical and thermal loads	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H											H	
CO2	H	H	M	M									H	
CO3	H	H	M	M									H	
CO4	H	M											H	
CO5	H	H	H	M									H	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION

L-9

Definitions: Composite material, Fiber, Matrix. Types of Fibers and Raw Fiber Properties, Types of Matrix, Prepegs, Fillers and other Additives. Advantages of Composite Materials and Structures. Applications and Use of Composite materials in present world. Mechanical Behaviour of Composite Materials. Lamina, Laminate: The basic building block of a composite material.

UNIT II MACROMECHANICAL ANALYSIS OF LAMINA

L-9

Lamina Assumptions – Macroscopic Viewpoint. Generalized Hooke's Law. Reduction to Homogeneous Orthotropic Lamina – Isotropic limit case, Orthotropic Stiffness matrix (Q_{ij}), Typical Commercial material properties, Generally Orthotropic Lamina –Transformation Matrix, Transformed Stiffness.

UNIT III MICROMECHANICAL ANALYSIS OF LAMINA

L-9

Properties of typical composite materials. Volume and Weight Fractions. Rule of Mixtures. Longitudinal Strength and Stiffness. Transverse Modulus. In-plane shear Modulus. Poisson's ratio.

UNIT IV MACROMECHANICAL ANALYSIS OF LAMINATE

L-9

Definition of stress and Moment Resultants. Strain Displacement relations. Basic Assumptions of Laminated anisotropic plates. Laminate Constitutive Equations – Coupling Interactions, Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates. Laminate Structural Moduli. Evaluation of Lamina Properties from Laminate Tests. Quasi-Isotropic Laminates. Determination of Lamina stresses within Laminates.

UNIT V LAMINA STRENGTH ANALYSIS

L-9

Introduction - Maximum Stress and Strain Criteria. Von-Mises Yield criterion for Isotropic Materials. Generalized Hill's Criterion for Anisotropic materials. Tsai-Hill's Failure Criterion for Composites. Tensor Polynomial (Tsai-Wu) Failure criterion. Prediction of laminate Failure.

TOTAL: 45 PERIODS

8. Text Books

1. Mallick, P.K., Fiber, Reinforced Composites: Materials, Manufacturing and Design, Manel Dekker Inc, 1993.

9. References

1. Jones, R.M., "Mechanics of Composite Materials", McGraw-Hill, Kogakusha Ltd., Tokyo, 1985.
2. Gibson, R.F., "Principles of Composite Material Mechanics", Second Edition, McGraw-Hill, CRC press in progress, 1994,
3. Mechanics of Composite Materials, Autar K. Kaw, 2nd ed., CRC Press, 2006
4. Engineering Mechanics of Composite Materials, I. M. Daniel, O. Ishai, Oxford University Press, 2006.
5. Hyer, M.W., "Stress Analysis of Fiber-Reinforced Composite Materials", McGraw-Hill, 1998.
6. Agarwal, B.D., and Broutman, L.J., "Analysis and Performance of Fibre Composites", John Wiley and sons. Inc., New York, 1995.

COURSE CODE	TOOL DESIGN ENGINEERING	L	T	P	C
10212ME102		3	0	0	3

1. Preamble

This course provides an introduction to the basic components and techniques of Tool engineering & its classification, materials heat treatment etc., Understanding of press tools & basic plastic moulding, analysis of mold flow and tool maintenance.

2. Pre-requisite

10211ME205-Machining And Machine Tools Technology

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- To understand the various types of cutting tools and tool materials.
- Understand the functions and design principles of press tools.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Draw the nomenclature of cutting tools and describe the classification, properties, and applications of cutting tools.	K3
CO2	Draw the nomenclature and choose multi point cutting tools for drilling, milling, reaming, hobbing, and grinding operations.	K3
CO3	Explain the cutting tool material standards, specifications, and heat treatment procedure.	K2
CO4	Apply the selection procedure to design single point, drilling, reaming, and tapping tools for given applications.	K3
CO5	Apply selection procedure to design dies for punching, blanking, drawing, and bending operations.	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H											H	
CO2	H	H											H	
CO3	M	H				M							H	
CO4	H	H	M			L							H	
CO5	H	H	M			L							H	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I CUTTING TOOLS

L-9

Materials-properties, classification, selection, insert and coated tools, tool wear, and tool life. Recent developments and applications. Single Point Tools: Nomenclature, types and styles, Introduction of HSS and carbide insert type tools for turning, boring, shaping, planning and slotting operations. Design of form tools. Tools and holders for CNC applications, tools for dry machining.

UNIT II MULTIPPOINT CUTTERS

L-9

Nomenclature, classification and selection, construction methods, cutter setting, design and manufacture of drills, reamers, taps, dies, thread chasers, milling cutters, broaches, hobs and gear shaper cutters. Grinding- wheel specification and selection.

UNIT III TOOL MATERIALS & HEAT TREATMENT

L-9

Standards and specifications of materials – Tool materials, metals and non-metals - Selection of metal tool materials, Hardening, annealing of tool steels and its types. Aus tempering, Mar tempering and Isothermal annealing for tool steels,. Tool failures due to improper heat treatment like overheating, improper quenching and loading. ION Nitrating, Vacuum carburizing, Chemical Vapour deposition. Heat treatment of non-ferrous materials-Aluminum Alloys.

UNIT IV ROLE OF DESIGN

L-9

Construction & design: single point tools, drills, reamers, ground thread taps, periphery cutting tools, broach, hobs –Selection & application role of design in the performance of cutting tools on ferrous and nonferrous work materials.

UNIT V PRESS TOOLS

L-9

Design and manufacture of die sets for sheet metal components-simple, compound and progressive dies for punching and blanking operations. Dies for drawing and bending operations. Selection of presses and tools.

TOTAL: 45 PERIODS

8. Text Books

1. Donaldson C and LeCain C H, "Tool Design", Tata McGraw Hill Publishing Company Ltd., New Delhi, 2004.
2. Bhattacharyya A, "Metal Cutting Theory and Practice", New Central Books Agency (P) Ltd, Calcutta, 2000.
3. Cracknell P C and Dyson R W, "Handbook of Thermoplastics Injection Mould Design", Chapman and Hall, 1993.
4. Mikell P Groover, "Fundamentals of Modern Manufacturing", John Wiley and Sons, Singapore, 2004.

9. References

1. SME, "Manufacturing Engineers Hand Book", 1998.
2. Rodin P, "Design and Production of Metal cutting Tools", MIR Publishers, Moscow, 1968.

COURSE CODE	INDUSTRIAL TRIBOLOGY	L	T	P	C
10212ME103		3	0	0	3

1. Preamble

This course provides knowledge of various engineering surfaces and friction in mechanical systems. It also introduces concepts associated with devices such as design of surfaces lubrication of surfaces, wear and tear.

2. Pre-requisite

10211ME103-Materials and Metallurgy

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- To educate the students on the importance of friction, the related theories/laws of sliding and rolling friction and its effect on different surfaces.
- To expose the students to the significances of wear, wear mechanisms, wear theories and measurement techniques.
- To introduce film lubrication theory and characteristics to select journal bearing applications.
- To impart the knowledge on lubrication, lubrication regimes, theories of hydrodynamic and advanced lubrication techniques.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Choose suitable measurement techniques to measure friction on any engineering surface.	K3
CO2	Choose suitable measurement techniques for different frictional surface conditions.	K3
CO3	Use Reynolds and Sommerfeld number to analyze the load capacity, friction and lubricant flow for journal bearing.	K3
CO4	Compare and contrast the lubrication processes and lubricants in a given system for specific applications.	K3
CO5	Select a suitable material and surface improvement methods for fluid film and dry bearings.	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M										L	M	
CO2	H	M										L	M	
CO3	H	H	M				L	L				M	H	M
CO4	H	H	L						L	L		H	H	
CO5	H	H					L	L				H	H	M

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I SURFACES AND FRICTION

L-9

Introduction to the concept of tribology- Nature of engineering surfaces- Surface topography - Contact between surfaces - Sources of sliding friction – Friction characteristics of metals and non-metals - Friction due to adhesion- Friction due to ploughing- Rolling friction - Source of rolling friction- Stick slip motion- Friction of ceramic materials and polymers- Measurement of friction.

UNIT II WEAR

L-9

Background of Wear- Types of wear with applications – Wear mechanisms- Abrasive wear- Adhesive wear- corrosive wear- Fretting Wear- Wear in metals- Wear in ceramic and polymers- Wear measurement.

UNIT III FILM LUBRICATION THEORY

L-9

Fluid film in simple shear - Viscous flow between very close parallel plates - Shear stress variation Reynolds equation for film lubrication - High speed unloaded journal bearings - Loaded journal bearings – Somerfield no.

UNIT IV LUBRICANTS AND LUBRICATION TYPES

L-9

Types and properties of Lubricants- Lubricants Additives- Importance of lubrication- Hydrodynamic Lubrication – Elasto hydrodynamic lubrication- Boundary Lubrication - Solid Lubrication- Hydrostatic Lubrication.

UNIT V SURFACE ENGINEERING AND MATERIALS FOR BEARINGS

L-9

Surface modifications - Transformation hardening - Surface fusion - Thermo chemical processes –Surface coatings - Plating and anodizing - Materials for rolling element bearings - Materials for fluid film bearings - Materials for marginally lubricated and dry bearings.

TOTAL: 45 PERIODS

8. Text Books

1. Hutchings.I.M and Shipway P, “Tribology, Friction and Wear of Engineering Material, Elsevier Butterworth –Heinemann, UK, 2017.
2. Bharat Bhushan, “Introduction to tribology”, Wiley Publication, 2013.
3. Williams, J. A., Engineering Tribology, Oxford University Press, 1994.

9. References

1. GwidonStachowiak, Andrew W Batchelor., “Engineering tribology”, Elsevier Butterworth –Heinemann, USA, 2005.
2. Stolarski T. A., Tribology in Machine Design, Industrial Press Inc., 1990.
3. Bowden, E. P., and Tabor. D., Friction and Lubrication, Heinemann Educational Books Ltd., 1974.
4. Cameron, A., Basic Lubrication theory, Longman, U.K., 1981.
5. Neale, M. J., (Editor), Tribology Handbook, Newnes Butter worth, Heinemann, U.K., 1975

COURSE CODE	GEOMETRICAL DIMENSIONS AND TOLERANCES	L	T	P	C
10212ME104		2	1	0	3

1. Preamble

This course provides adequate knowledge in geometrical dimensions and tolerances and their role in manufacturing industries. It also introduces PLC and its applications.

2. Pre-requisite

10210ME201-Engineering Graphics

3. Link to the other courses

10211ME206-Measurements and Control

4. Course Educational Objectives

Students, after undergoing this course would

- To understand the fundamentals of different tolerances.
- To understand the classification of fits and their design.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Draw and describe geometric dimensioning and tolerance symbols for the given features.	K3
CO2	Classify the types of datum and their applications in geometrical features.	K3
CO3	Choose and apply material condition symbols to the given features	K3
CO4	Identify and apply geometrical tolerance symbols for the given features.	K3
CO5	Apply the position tolerance for the given features.	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H										M	M	H
CO2	H	H			M							M	M	H
CO3	H	H			M							M	M	H
CO4	H	H			M							M	M	H
CO5	H	H			M							M	M	H

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I TOLERANCE AND FIT TYPES

L-6 T-3

General tolerancing – tolerances, limits, specified dimension, extreme form variation, clearance fit, allowance, interference fit. Symbols and terms – geometric characteristic symbols, material condition symbols, datum feature, feature control frame, basic dimension, dimensioning symbols.

UNIT II TYPES OF DATUMS

L-6 T-3

Datums – datum feature symbol, datum features, high point contact, specific point contact, datum frame, datum axis, partial datums, and datum center plane.

UNIT III MATERIAL CONDITION

L-6 T-3

Material condition symbols – maximum material condition, regardless of feature size, least material condition, applications.

UNIT IV GEOMETRIC CHARACTERISTICS AND FEATURES

L-6 T-3

Geometric characteristics – straightness, flatness, circularity, cylindricity, profile, parallelism, perpendicularity, angularity, runout, combination of geometric characteristics.

UNIT V TYPES OF TOLERANCE POSITION

L-6 T-3

Position – conventional tolerancing vs. positional tolerancing, floating fasteners, fixed fasteners, positional tolerance at MMC, zero positional tolerance, virtual condition projected tolerance zone, composite positional tolerance, two single-segment feature control frame, concentricity, symmetry.

TOTAL: 45 PERIODS

8. Text Books

1. Carissa Ann Kalpakjian and Shelly Petronis, "Manufacturing Engineering and Technology, Pearson Education, 2004.
2. Jason E Tynes," Introduction to Tolerance Analysis for Mechanical Engineers, Second Edition, 2013.

COURSE CODE	CORROSION ENGINEERING	L	T	P	C
10212ME105		3	0	0	3

1. Preamble

This course provides general issues relating to corrosion and prevention of corrosion.

2. Pre-requisite

10211ME103-Materials and Metallurgy

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Different types of corrosion on engineering structures and their impacts.
- Correlate materials theory with practical applications.
- About design and selection of materials to prevent different types of corrosion.
- Behavior of materials
- Surface coating process

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describe the factors influencing corrosion and classify different types of corrosion.	K3
CO2	Illustrate the corrosion testing procedure and its prevention methods.	K3
CO3	Describe the corrosion behaviour of alloys and ceramic materials.	K2
CO4	Distinguish and choose a suitable coating for wear and corrosion resistance.	K3
CO5	Explain the mechanism, types and applications of thin layer coatings for engineering processes.	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H					L						M	
CO2	H	H					L						M	
CO3	H	H					L						M	
CO4	H	H			L		L						M	
CO5	H	H			L		L						M	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I MECHANISMS AND TYPES OF CORROSION

L-9

Cost of corrosion, corrosion rate expression, Principles of direct and Electro chemical corrosion, Hydrogen evolution and oxygen absorption mechanisms - Galvanic corrosion, Galvanic series -Specific types of corrosion such as, Uniform, pitting, Intergranular, Cavitations, Crevice, Fretting, Erosion and Stress corrosion - Factors influencing corrosion.

UNIT II TESTING AND PREVENTION OF CORROSION

L-9

Corrosion testing techniques and procedures - Materials selection- Prevention of corrosion -Design against corrosion – Modification of corrosive environment - Inhibitors - Cathodic protection - Protective surface coatings.

UNIT III CORROSION BEHAVIOUR OF MATERIALS

L-9

Corrosion of Steels, Stainless steels, Aluminum alloys, Copper alloys, Magnesium and alloys Nickel and Titanium alloys - Corrosion of polymers, Ceramics and composite materials.

UNIT IV SURFACE ENGINEERING FOR WEAR AND CORROSION RESISTANCE

L-9

Diffusion coatings - Electro and Electro less plating - Hot dip coating - Hard facing - Metal spraying, Flame and Arc processes - Conversion coatings -Selection of coating for wear and corrosion resistance.

UNIT V THIN LAYER ENGINEERING PROCESSES

L-9

Laser and Electron Beam hardening – Physical vapour deposition, Thermal evaporation, Arc vaporization, Sputtering, Ion plating - Chemical vapour deposition -Coating of tools, TiC, TiN, Al₂O₃ and Diamond coating properties and applications of thin coatings.

TOTAL: 45 PERIODS

8. Text Books

1. Fontana, G., "Corrosion Engineering ", McGraw-Hill, 1985.
2. Schweitzer P.A., "Corrosion Engineering Hand Book ", 3rd Edition, Marcel Decker, 1996.

9. References

1. Winston Revie, R, Uhlig's " corrosion, Hand Book ", 2nd Edition, JohnWiley, 2000.
2. Kammeth G. Budinski, "Surface Engineering for Wear resistance ", Prentice Hall, 1988.
3. Metals Handbook, Vol.5, "Surface Engineering ", ASM International, 1996.

COURSE CODE	EXPERIMENTAL STRESS ANALYSIS	L	T	P	C
10212ME106		3	0	0	3

1. Preamble

To study the various experimental techniques involved for measuring displacements, stresses, strains in structural components.

2. Pre-requisite

10211ME206-Measurements and Control

3. Link to the other courses

10211ME203-Finite Element Analysis

4. Course Educational Objectives

Students, after undergoing this course would

- Know the principles, methods, areas of usage, and limitations of the stress, strain, displacement in structural components.
- Be familiar with mathematical and experimental correlation to fully understand stress and strain measurement.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Illustrate the construction and working principle of force and strain measurement instruments.	K3
CO2	Choose suitable measuring instruments for vibration measurement applications.	K3
CO3	Explain the working principle of measuring instruments used for acoustics and wind flow applications.	K2
CO4	Describe the methods used to identify and control the cracks and damage in structural applications.	K2
CO5	Illustrate the non-destructive testing methods for structure, buildings, bridges, and towers applications.	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

Correlation of COs with POs

6.

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M											H	
CO2	H	M			L								H	L
CO3	H	M											H	
CO4	H	M											H	
CO5	H	M											H	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I FORCES AND STRAIN MEASUREMENT

L-9

Strain gauge, principle, types, performance and uses. Photo elasticity –Principle and applications - Moire Fringe - Hydraulic jacks and pressure gauges – Electronic load cells – Proving Rings – Calibration of Testing Machines.

UNIT II VIBRATION MEASUREMENTS

L-9

Characteristics of Structural Vibrations – Linear Variable Differential Transformer (LVDT) – Transducers for velocity and acceleration measurements. Vibration meter – Seismographs – Vibration Analyzer – Display and recording of signals – Cathode Ray Oscilloscope – XY Plotter – Chart Plotters – Digital data Acquisition systems.

UNIT III ACOUSTICS AND WIND FLOW MEASURES

L-9

Principles of Pressure and flow measurements – pressure transducers – sound level meter – venturimeter and flow meters – wind tunnel and its use in structural analysis – structural modeling – direct and indirect model analysis.

UNIT IV DISTRESS MEASUREMENTS

L-9

Diagnosis of distress in structures – crack observation and measurements – corrosion of reinforcement in concrete – Half-cell, construction and use – damage assessment – controlled blasting for demolition.

UNIT V NON DESTRUCTIVE TESTING METHODS

L-9

Load testing on structures, buildings, bridges and towers – Rebound Hammer – acoustic emission – ultrasonic testing principles and application – Holography – use of laser for structural testing – Brittle coating.

TOTAL: 45 PERIODS

8. Text Books

1. Sadhu Singh – Experimental Stress Analysis, Khanna Publishers, New Delhi, 2010.
2. Srinath, L.S., Raghava, M.R., Lingaiah, K., Garagesha, G., Pant B., and Ramachandra, K., “Experimental Stress Analysis”, Tata McGraw-Hill, New Delhi, 1984.

9. References

1. JW Dalley and WF Riley, Experimental Stress Analysis, McGraw Hill Book Company, N.Y. 2011
2. R.S.Sirohi, HC Radhakrishna, Mechanical Measurements, New Age International (P) Ltd. 2008
3. F.K Garas, J.L. Clarke and GST Armer, Structural assessment, Butterworths, London, 2012
4. D.E. Bray& R. K.Stanley, Non-destructive Evaluation, McGraw Hill Publishing Company, N.Y.2009

COURSE CODE	APPLIED HYDRAULICS AND PNEUMATICS	L	T	P	C
10212ME107		3	0	0	3

1. Preamble

This course provides adequate knowledge in hydraulics and pneumatics circuits and their role in manufacturing industries. It also introduces PLC and its applications.

2. Pre-requisite

10210EE201-Basic Electrical, Electronics and Measurement Engineering

3. Link to the other courses

10211ME207-Mechatronics system

4. Course Educational Objectives

Students, after undergoing this course would

- To understand the fundamentals of fluid power transmission systems
- To design various hydraulic and pneumatic system components.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Draw performance curves of variable displacement pumps.	K3
CO2	Explain the construction and types of actuators and valves used in hydraulic control systems.	K2
CO3	Explain the construction and types of actuators and valves used in pneumatic control systems.	K2
CO4	Develop simple and sequential circuits for fluidics and pneumatic system using classic, cascade, and step counter methods.	K3
CO5	Construct fluid power circuits for the given specifications and applications.	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	L										M	
CO2	M	L	L										M	
CO3	M	L	L										M	
CO4	H	H	H		M	L		M				M	M	H
CO5	H	H	H		M	L		M				M	M	H

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I FLUID POWER PRINCIPLES AND HYDRAULIC PUMPS L-9

Introduction to fluid power, Advantages of fluid power, Application of fluid power system. Types of fluid power systems, General types of fluids – Properties of hydraulic fluids – Basics of Hydraulics -Applications of Pascal's Law Sources of Hydraulic Power: Pumping theory – Pump classification –construction and working of pumps – Variable displacement pumps, pump performance- Problem

UNIT II HYDRAULIC ACTUATORS AND CONTROL COMPONENTS L-9

Actuators: Linear hydraulic actuators– Single acting and double acting cylinders, Rotary actuators – Fluid motors- Problem. Control Components: Direction control valve – Valve terminology - Various center positions. Shuttle valve – check valve – pressure control valve – pressure reducing valve, sequence valve. Flow control valves – Fixed and adjustable. Safety valves- Fluid power symbols.

UNIT III PNEUMATIC SYSTEM COMPONENTS L-9

Pneumatic Components: Properties of air. Compressors. FRL Unit, – Air control valves, Quick exhaust valves and pneumatic actuators – Selection criteria for pneumatic components - cylinders, air motors. Basics of low-cost automation

UNIT IV FLUIDICS &PNEUMATIC CIRCUIT DESIGN L-9

Fluidics – Introduction to fluidic devices, simple circuits Introduction to Electro Hydraulic Pneumatic logic circuits, PLC applications in fluid power control, Sequential circuit design for simple applications using classic, cascade, step counter, logic with Karnaugh- Veitch Mapping and combinational circuit design methods.

UNIT V FLUID POWER CIRCUITS L-9

Speed control circuits, synchronizing circuit, Pneumo hydraulic circuit, Accumulators and Intensifiers- Accumulator circuits, Intensifier circuits. Servo systems – Hydro Mechanical servo systems, Electro hydraulic servo systems and proportional valves. Deceleration circuit, hydrostatics transmission circuits, control circuits for reciprocating drives in machine tools, Material handling equipments. Fluid power circuits; failure and troubleshooting.

TOTAL: 45 PERIODS

8. Text Books

1. Majumdar S.R., "Pneumatic systems – Principles and maintenance", Tata McGraw Hill, 2008
2. Anthony Esposito, "Fluid Power with Applications", Pearson Education 2013.

9. References

1. Majumdar S.R., "Oil Hydraulics", Tata McGraw-Hill, 2000.
2. Harry L. Stevart D.B, "Practical guide to fluid power", Taraoeala sons and Port Ltd.Broadey, 2010.
3. Michael J, Prinches and Ashby J. G, "Power Hydraulics", Prentice Hall, 2011.
4. Dudelyt, A. Pease and John T. Pippenger, "Basic Fluid Power", Prentice Hall, 2011.

COURSE CODE	JIGS, FIXTURES AND PRESS TOOLS	L	T	P	C
10212ME108		2	0	0	3

1. Preamble

This course provides the knowledge on different locating and clamping, pressing, bending and forming techniques and principles.

2. Pre-requisite

10211ME205-Machining and Machine Tools Technology

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the principles of locating and clamping methods, and functions of Jigs and fixtures
- Understand the press working terminologies and design and development of bending, drawing and forming dies.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Illustrate the working principle, types, and methods of locating and clamping devices.	K3
CO2	Design and develop jigs and fixtures for the given components.	K3
CO3	Design and prepare four standard views of simple blanking, piercing, compound and progressive dies.	K3
CO4	Develop bending, forming, and drawing dies and blank development for given parts	K3
CO5	Explain the various forming techniques and numerical control for sheet metal forming	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H											H	
CO2	H	H	L		L	M		L					H	M
CO3	H	H	L		L	M		L					H	M
CO4	H	H	L		L	M		L					H	M
CO5	H	H											H	M

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I LOCATING AND CLAMPING PRINCIPLES

L-9

Principles of location – Locating methods and devices – Locating from a flat surface, Locating from an internal diameter, Locating from an external diameter, Locating from external profile, Ejectors, Spring stop buttons – Redundant Location – Principles of clamping – Mechanical actuation – pneumatic and hydraulic actuation Standard parts – Clamping Methods and types of clamping

UNIT II JIGS AND FIXTURES

L-9

Drill bushes and Jig buttons – Types of Jigs – Post, Turnover, Channel, latch, box, pot, angular post jigs – Indexing jigs – design of jigs for drilling – General principles of milling, Lathe, boring, broaching and grinding fixtures – Assembly, Inspection and Welding fixtures – Modular fixturing systems- Quick change fixtures. Design and development of jigs and fixtures for given component.

UNIT III PRESS WORKING TERMINOLOGIES AND ELEMENTS OF CUTTING DIES

L-9

Press Working Terminologies – operations – Types of presses – press accessories – Computation of press capacity – Strip layout – Material Utilization – Shearing action – Clearances – Press Work Materials – Center of pressure-Types of dies – progressive, compound and combination dies – Design of various elements of dies – Die Block – Punch holder, Die set, guide plates – Stops – Strippers – Pilots – Materials for Die Block – Selection of Standard parts – Design and preparation of four standard views of simple blanking, piercing, compound and progressive dies.

UNIT IV BENDING AND DRAWING DIES

L-9

Types of Bending dies – Press capacity – Spring back – knockouts – direct and indirect – pressure pads – Ejectors – Variables affecting Metal flow in drawing operations – draw die inserts – draw beads-ironing – Design and development of bending, forming, drawing, reverse redrawing and combination dies – Blank development for axisymmetric, rectangular and elliptic parts.

UNIT V OTHER FORMING TECHNIQUES

L-9

Bulging, Swaging, Embossing, coining, curling, hole flanging, shaving and sizing, assembly, fine Blanking dies – recent trends in tool design- computer Aids for sheet metal forming Analysis – basic introduction – tooling for numerically controlled machines- setup reduction for work holding – Single minute exchange of dies – Poka Yoke.

TOTAL: 45 PERIODS

8. Text Books

1. Joshi, P.H. "Jigs and Fixtures", Second Edition, Tata McGraw Hill Publishing Co., Ltd., New Delhi, 2004.
2. Joshi P.H "Press tools – Design and Construction", wheels publishing, 1996.

9. References

1. Venkataraman. K., "Design of Jigs Fixtures & Press Tools", Tata McGraw Hill, New Delhi, 2005.
2. Donaldson, Lecain and Goold "Tool Design", 3rd Edition, Tata McGraw Hill, 2000
3. Kempster, "Jigs and Fixture Design", Third Edition, Hoddes and Stoughton, 1974.
4. Hoffman "Jigs and Fixture Design", Thomson Delmar Learning, Singapore, 2004.
5. STME Fundamentals of Tool Design Prentice Hall of India. 6. Design Data Hand Book, PSG College of Technology, Coimbatore.

COURSE CODE	NON-DESTRUCTIVE TESTING	L	T	P	C
10212ME109		3	0	0	3

1. Preamble

This course provides the understanding on various non-destructive evaluation and testing methods, theory and their industrial applications.

2. Pre-requisite

10211ME103-Materials and Metallurgy

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Explain the importance and different methods of NDT.
- Explain procedural steps involved in Liquid Penetrate and Eddy Current Testing.
- Describe the fundamental principle and testing procedures of Magnetic Particle Inspection and Thermograph.
- Explain the principles and different testing methods of Ultrasonic and Radiography Testing methods.
- Explain the principles and different testing methods of radiography.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Distinguish between destructive and Non-destructive Tests, Codes, standards, specifications and procedures.	K3
CO2	Explain the principles and testing of LPT, ECT & ACT methods for product testing.	K2
CO3	Describe the materials and testing procedure for magnetic particle and thermography testing.	K2
CO4	Explain the principle of wave propagation, flaw detection and inspection methods of ultrasonic testing of products.	K2
CO5	Explain the principle of radiography, equipment and inspection methods of ultrasonic testing of products.	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H											M	
CO2	H	H											M	
CO3	H	H											M	L
CO4	H	H				H	H	H					M	L
CO5	H	H				H	H	H					M	L

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I BASICS OF NDT & LIQUID PENETRANT TESTING

L-9

Introduction to various non-destructive methods, Comparison of Destructive and Non-destructive Tests, Codes, standards, specification and procedures. Visual Inspection, Optical aids used for visual inspection, Applications.

Liquid Penetrant Testing – Physical principles & procedure for penetrant testing, Penetrant testing materials, Penetrant testing methods-water washable, Post – Emulsification

methods, Advantages and Limitations, Applications. Case studies by taking various manufacturing defects.

UNIT II EDDY CURRENT TESTING & ACOUSTIC EMISSION

L-9

Principles, Instrumentation for ECT, Absolute, differential probes, Techniques – High sensitivity techniques, Phased array ECT, Advantages and Limitations, Applications. Principle of AET, Procedure, Instrumentation, Advantages and Limitations, Applications. Case studies on both ECT and AE.

UNIT III MAGNETIC PARTICLE TESTING & THERMOGRAPHY

L-9

Principle of MPT, procedure used for testing a component, Equipment used for MPT, Magnetizing techniques, Advantages and Limitations, Applications. Principle of Thermography, Infrared Radiometry, Active thermography measurements, Advantages and Limitations, Applications, Case studies based on MPT and Thermography.

UNIT IV ULTRASONIC TESTING

L-9

Principle of Wave Propagation, Reflection, Refraction, Diffraction, Mode Conversion and Attenuation, Sound Field, Piezo-electric Effect, Ultrasonic transducers, Ultrasonic Flaw detection Equipment, Modes of display A- scan, BScan, C- Scan, Applications, Inspection Methods - Normal Incident Pulse-Echo Inspection, Normal Incident Through-transmission Testing, Angle Beam Pulse-Echo testing, Advantages and Limitations, Applications, Case studies.

UNIT V RADIOGRAPHY

L-9

Principle of Radiography, Types, Sources of X and Gamma Rays and their interaction with Matter, Radiographic equipment, Effect of radiation on Film, Radiographic imaging, Inspection Techniques – Single wall single image, Double wall Penetration, Multiwall Penetration technique, Real Time Radiography, Advantages and Limitations, Applications, Safety Aspects of Industrial Radiography, Case studies.

TOTAL: 45 PERIODS

8. Text Books

1. Baldev Raj, Jeyakumar, T, Thavasimuthu M, “Practical Non Destructive Testing” Narosa publishing house, New Delhi, 2006.

9. References

1. Krautkramer. J., “Ultra Sonic Testing of Materials”, 1st Edition, Springer – Verlag Publication, New York, 1996.
2. Peter J. Shull “Non Destructive Evaluation: Theory, Techniques and Application” Marcel Dekker, Inc., New York, 2002.
3. Non-destructive test and evaluation of Materials, J Prasad, GCK Nair, TMH Publishers. 2011

COURSE CODE	NON-TRADITIONAL MACHINING PROCESSES	L	T	P	C
10212ME110		3	0	0	3

1. Preamble

This course addresses additive manufacturing principles, variety and its concept, scope of additive manufacturing and areas of application.

2. Pre-requisite

10211ME205-Machining and Machine Tools Technology

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Acquire a functional understanding of non-traditional manufacturing equipment.
- Understand the terminology used in non-traditional manufacturing industries.
- To provide knowledge on the classification of non-traditional machining process.
- Know about various process parameters and their influence on performance and their applications.
- Impart knowledge on various energy involved in non-traditional machining process.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Classify non-traditional machining processes based on selection criteria	K3
CO2	Illustrate the effect of AJM, WJM, and USM process parameters on material removal rate.	K3
CO3	Illustrate the effect of EDM and WEDM process parameters on material removal rate.	K3
CO4	Illustrate the effect of CHM, ECM, ECH, and ECG process parameters on material removal rate.	K3
CO5	Illustrate the effect of LBM, EBM, and PAM process parameters on material removal rate.	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H											H	
CO2	H	H	L				H	L					H	
CO3	H	H	L				H	L					H	
CO4	H	H	L				H	L					H	
CO5	H	H	L				H	L					H	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I UNCONVENTIONAL MACHINING PROCESSES

L-9

Introduction - Need - Classification - Energies employed in the processes - Brief overview of Abrasive jet machining (AJM), Water jet machining (WJM), Abrasive Water jet machining (AWJM), Ultrasonic machining (USM), Electric discharge machining (EDM), Electro-chemical machining (ECM), Electron beam machining (EBM), Laser beam machining (LBM), Plasma arc machining (PAM).

UNIT II MECHANICAL ENERGY BASED PROCESSES**L-9**

Abrasive Jet Machining, Water Jet Machining, Abrasive Water Jet Machining and Ultrasonic Machining - Working Principles, Equipment, Process parameters, Material removal rate, Applications.

UNIT III ELECTRICAL ENERGY BASED PROCESSES**L-9**

Electric Discharge Machining - Working Principles, Equipment, Process Parameters, Material removal rate, Electrode / Tool, Power Circuits, Tool Wear, Dielectric, Flushing, Machining characteristics of spark eroded surface, Wire cut EDM – Applications. Introduction to Electric Discharge Grinding.

UNIT IV CHEMICAL AND ELECTRO-CHEMICAL ENERGY BASED PROCESSES L-9

Chemical machining - Etchants, Maskants - techniques. Electro-chemical machining – Working principle, Equipment, Process Parameters, Material removal rate, Electrical circuit. Electro-chemical grinding - Electro-chemical honing - Applications.

UNIT V THERMAL ENERGY BASED PROCESSES**L-9**

Laser Beam machining, Plasma Arc Machining, Ion Beam Machining - Principles, Equipment. Electron Beam Machining, - Principles, Equipment, Types, Beam control techniques, Material removal rate - Applications.

BEYOND THE SYLLABUS

Abrasive finishing - Electro-stream drilling- Electro-chemical deburring, Micro ECM

TOTAL: 45 PERIODS**8. Text Books**

1. P. K. Mishra, Non-Conventional Machining, Narosa Publishing House, New Delhi, 2007.
2. P. C. Pandey and H.S. Shan, Modern Machining Processes, Tata McGraw Hill Publishing
3. Company Pvt Ltd., New Delhi, 2008.
3. Joao Paulo Davim, Nontraditional Machining Processes: Research Advances, Springer, New York, 2013.

9. References

1. Paul De Garmo, J.T. Black, and Ronald.A. Kohser, Material and Processes in Manufacturing, Prentice Hall of India Pvt. Ltd., New Delhi, 2011.
2. Vijaya Kumar Jain, Advanced Machining Processes, Allied Publishers Pvt. Ltd., New Delhi, 2005.
3. Hassan El-Hofy, Advanced Machining Processes: Non-traditional and Hybrid Machining Processes, McGraw-Hill Professional, New Delhi, 2005

COURSE CODE	PROCESS PLANNING AND COST ESTIMATION	L	T	P	C
10212ME111		3	0	0	3

1. Preamble

This course provides an introduction about process planning and its activities. It introduces the procedure of cost estimation of products manufactured in different shops and also machine time evaluation.

2. Pre-requisite

10211ME205-Machining and Machine Tools Technology

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Introduce the process planning concepts to make cost estimation for various products after process planning.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describe the steps involved in the selection of process, equipment, and tooling.	K2
CO2	Calculate process parameters for the given production processes.	K3
CO3	Estimate labor, material, and depreciation cost for the given jobs.	K3
CO4	Estimate the production cost for welding and foundry operations using Taylor's equation.	K3
CO5	Estimate machining time for Lathe, drilling, boring, shaping, and milling operations.	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M									M		H	
CO2	H	H									M		H	H
CO3	H	H			L						H		H	H
CO4	H	H			L						H		H	H
CO5	H	H			L						H		H	H

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION TO PROCESS PLANNING

L-9

Introduction- methods of process planning-Drawing interpretation-Material evaluation – steps in process selection-Production equipment and tooling selection.

UNIT II PROCESS PLANNING ACTIVITIES

L-9

Process parameters calculation for various production processes-Selection jigs and fixtures-Selection of quality assurance methods - Set of documents for process planning- Economics of process planning- case studies- Process Capability - Process charts.

UNIT III INTRODUCTION TO COST ESTIMATION**L-9**

Importance of costing and estimation –methods of costing-elements of cost estimation – Types of estimates – Estimating procedure- Estimation labor cost, material cost-allocation of overhead charges- Calculation of depreciation cost - Preparation of process chart for a given component.

UNIT IV PRODUCTION COST ESTIMATION**L-9**

Estimation of Different Types of Jobs - Estimation of Forging Shop, Estimation of Welding Shop, Estimation of Foundry Shop - Use of computers in cost estimation- Optimum machining conditions - Taylors equation, Deriving the equation for optimum economic cutting velocity - Selection of cutting speed for optimum cost-Problems.

UNIT V MACHINING TIME CALCULATION**L-9**

Estimation of Machining Time - Importance of Machine Time Calculation- Calculation of Machining Time for Different Lathe Operations ,Drilling and Boring - Machining Time Calculation for Milling, Shaping and Planning -Machining Time Calculation for Grinding.

TOTAL: 45 PERIODS**8. Text Books**

1. Peter scalon, "Process planning, Design/Manufacture Interface", Elsevier science technology Books, 2003.
2. Sinha.B.P, "Mechanical Estimating and Costing", Tata McGraw-Hill Publishing Co., 1995.
3. Phillip.F Ostwalal and Jairo Munez, "Manufacturing Processes and systems", John Wiley, 9th Edition, 2008.
4. Chitale, A. K., and Gupta, R. C., "Product Design and manufacturing", Prentice Hall of India, New Delhi, 6th Edition 2013.
5. Adithan, M. S., and Pabla, "Production Engineering Estimating and Costing", Konark Publishers Pvt., Ltd. 1989.

9. References

1. Ostwalal P.F. and Munez J., "Manufacturing Processes and systems", 9th Edition, John Wiley, 1998.
2. Russell R.S and Tailor B.W, "Operations Management", 4th Edition, PHI, 2003.
3. Banga T.R and Sharma.S.C, "Estimating and costing", Khanna Publishers, New Delhi, 16th Edition, 2011.
4. Nanua Singh, "System Approach to Computer Integrated Design and Manufacturing", John Wiley & Sons, New York, 2011.

COURSE CODE	ADDITIVE MANUFACTURING	L	T	P	C
10212ME112		3	0	0	3

1. Preamble

This course addresses additive manufacturing principles, variety and its concept, scope of additive manufacturing and areas of application.

2. Pre-requisite

Machining and Machine Tools Technology

3. Link to the other courses

Computer Aided Design and FEA

4. Course Educational Objectives

Students, after undergoing this course would

- Know the principles, methods, areas of usage, possibilities and limitations as well as environmental effects of the additive manufacturing technologies
- Be familiar with the characteristics of various materials that are used in additive manufacturing.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describe the differences and applications of additive manufacturing processes.	K2
CO2	Explain data acquisition methods used for reverse engineering and use of CAD for part generation.	K2
CO3	Describe the operating principles, capabilities, and limitations of SLA, FDM, and LO additive manufacturing systems.	K2
CO4	Describe the operating principles, capabilities, and limitations of SLS, 3DP, and LENS additive manufacturing systems.	K2
CO5	Select the suitable additive manufacturing technique for bio-medical applications.	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M											M	
CO2	H	M			H					M		L	M	M
CO3	H	M			M								M	M
CO4	H	M			M								M	M
CO5	H	M			M								M	M

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION

L-9

Overview – History – Need-Classification -Additive Manufacturing Technology in product development-Materials for Additive Manufacturing Technology – Tooling – Applications.

UNIT II CAD & REVERSE ENGINEERING

L-9

Basic Concept – Digitization techniques – Model Reconstruction – Data Processing for Additive Manufacturing Technology: CAD model preparation – Part Orientation and support generation – Model Slicing –Tool path Generation – Software's for Additive Manufacturing Technology: MIMICS, MAGICS.

Classification – Liquid based system – Stereolithography Apparatus (SLA) - Principle, process, advantages and applications – Solid based system –Fused Deposition Modeling – Principle, process, advantages and applications, Laminated Object Manufacturing.

Selective Laser Sintering – Principles of SLS process – Process, advantages and applications, Three Dimensional Printing – Principle, process, advantages and applications- Laser Engineered Net Shaping (LENS), Electron Beam Melting.

Customized implants and prosthesis: Design and production. Bio-Additive Manufacturing-Computer Aided Tissue Engineering (CATE) – Case studies

8. Text Books

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

1. Liou L.W. and Liou F.W., "Rapid Prototyping and Engineering applications: A tool box for prototype development", CRC Press, 2007.
2. Hilton P.D. and Jacobs P.F., "Rapid Tooling: Technologies and Industrial Applications", CRC press, 2000.
3. Douglas Bryden, "CAD and Prototyping for Product Design", 2014

COURSE CODE	INTERNAL COMBUSTION ENGINES	L	T	P	C
10212ME113		3	0	0	3

1. Preamble

This course will be helpful for the students to enhance their knowledge in Internal Combustion engine.

2. Pre-requisite

10211ME105-Applied Engineering Thermodynamics

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- About basics of internal combustion engines.
- Apply knowledge on various components of internal combustion engine.
- Apply basic knowledge solving problems related to internal combustion engine efficiencies.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Classify heat engines and differentiate between SI and CI engines.	K3
CO2	Illustrate the principle parts, functions and estimate the performance of compression ignition engines.	K3
CO3	Illustrate the principle parts, functions and estimate the performance of spark ignition engines.	K3
CO4	Describe the stages of combustion and factors affecting the combustion of SI and CI engines.	K2
CO5	Explain the reasons for engine emission and its control methods.	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	L											M	
CO2	H	L					L						M	
CO3	H	L					L						M	
CO4	H	L					L						M	
CO5	H	L			L	H	H	H				M	M	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION

L-9

Engine, Heat Engine, Classifications, History of IC Engine, Difference between 2-stroke and 4 strokes, Basic components of IC Engine, Differences between SI and CI Engine, materials for various components.

UNIT II COMPRESSION IGNITION ENGINES

L-9

CI Engines, Ideal cycle and actual Diesel cycle, fuel supply system, air supply system, Ignition system, Lubrication system, problems related to the above.

UNIT III SPARK IGNITION ENGINES

L-9

SI Engines, Diesel cycle, fuel supply system, air supply system, Ignition system, Lubrication

system, problems related to the above.

UNIT IV COMBUSTION IN ENGINES

L-9

Equivalence ratio, Combustion in SI and CI Engines, stages of combustion in SI and CI engines, Parameters affecting the combustion, Knocking/Detonation, Scavenging, Super charging and turbo charging.

UNIT V EFFICIENCY IMPROVEMENT AND EMISSION NORMS

L-9

Various efficiency improvement methods like Swirler, piston coatings, piston geometry modifications, EGR, biodiesel, Emissions released from SI and CI Engines, Emission norms BS and EURO.

TOTAL: 45 PERIODS

8. Text Books

1. Ganesan V, "Internal Combustion Engines", Tata McGraw-Hill, 4th Edition 2017.
2. Mathur M. L and Sharma. R. P, "A Course in Internal Combustion Engines", Dharpal Rai & Sons, 2016 Reprint Edition.

9. References

1. Heywood J. B, "Internal Combustion Engine Fundamentals", McGraw Hill Book Co. NY, Second Edition 2018.
2. Heldt P. M, "High Speed Combustion Engines", Oxford & IBH publishing Co. India, 1985.

COURSE CODE	FUELS AND COMBUSTION	L	T	P	C
10212ME114		3	0	0	3

1. Preamble

This course makes an attempt to bring students various types of fuels (like liquid, solid and gaseous fuels) that are available depend on various factors such as costs, availability, storage, handling, pollution and landed boilers, furnaces and other combustion equipment's. The knowledge of the fuel properties helps in selecting the right fuel for the right purpose and for the efficient use of the fuel.

2. Pre-requisite

10210CH101-Engineering Chemistry

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Describes the environmental problems arising due to the advanced technology
- Explains and provides knowledge on the energy resources and their management without wastage and prevention of over-exploitation.
- Analysis of various types of pollution and its control methods for solving the problems arising due to them.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Determine the Calorific value of fuels of fuels and flue gases	K3
CO2	Explain the classifications, properties, and production process of solid and liquid fuels.	K2
CO3	Explain the classification, properties, and production process of gaseous fuels.	K3
CO4	Illustrate the types, mechanisms, and flame propagation of combustion.	K3
CO5	Explain the functions and design of burning equipment.	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M					L						M	
CO2	H	M					L	L					M	
CO3	H	M					L	L					M	
CO4	H	M					L	L					M	
CO5	H	M					L	L					M	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I CHARACTERIZATION

L-9

Fuels – History of fuels-Types and Characteristics of Fuels - Determination of Properties of Fuels - Fuels Analysis – GC-MS Analysis importance-Proximate and Ultimate Analysis - Moisture Determination - Calorific Value - Gross & Net Calorific Values - Calorimetry - DuLong's Formula for CV Estimation - Flue gas Analysis - Orsat Apparatus - Fuel & Ash Storage & Handling - Spontaneous Ignition Temperatures.

UNIT II SOLID FUELS & LIQUID FUELS**L-9****(a) Solid Fuels**

Types- Coal classification-composition - Properties - Calorific Value - ROM, DMMF, DAF and Bone Dry Basis - Ranking - Bulk & Apparent Density - Storage - Wash ability - Coking & Caking Coals – Renewable Solid Fuels - Biomass - Wood Waste - Agro Fuels - Manufactured Solid Fuels.

(b) Liquid Fuels

Types - Sources - Exploration of crude Petroleum-Petroleum Fractions - Classification - Refining - Properties of Liquid Fuels - Calorific Value, Specific Gravity, Flash & Fire Point, Octane Number, Cetane Number etc, - Alcohols - Tar Sand Oil - Liquefaction of Solid Fuels.

UNIT III GASEOUS FUELS**L-9**

Classification - Composition & Properties - Estimation of Calorific Value - Gas Calorimeter. Rich & Lean Gas - Wobbe Index - Natural Gas - Dry & Wet Natural Gas - Stripped NG - Foul & Sweet NG - LPG - LNG - CNG - Methane - Producer Gas - Gasifiers - Water Gas - Town Gas - Coal Gasification - Gasification Efficiency - Non - Thermal Route - Biogas - Digesters - Reactions - Viability - Economics.

UNIT IV COMBUSTION: STOICHIOMETRY & KINETICS**L-9**

Stoichiometry - Mass Basis & Volume Basis - Excess Air Calculation - Fuel & Flue Gas Compositions - Calculations - Rapid Methods - Combustion Processes - Stationary Flame - Surface or Flameless Combustion - Submerged Combustion - Pulsating & Slow Combustion Explosive Combustion. Mechanism of Combustion - Ignition & Ignition Energy - Spontaneous Combustion – Introduction to flame velocity, premixed and diffusion combustion - Flame Propagation - Solid, Liquid & Gaseous Fuels Combustion - Flame Temperature - Theoretical, Adiabatic & Actual - Ignition Limits - Limits of Inflammability.

UNIT V COMBUSTION EQUIPMENTS**L-9**

Coal Burning Equipment - Types - Pulverized Coal Firing - Fluidized Bed Firing - Fixed Bed & Recycled Bed - Cyclone Firing - Spreader Stokers - Vibrating Grate Stokers - Sprinkler Stokers, Traveling Grate Stokers. Oil Burners - Vaporizing Burners, Atomizing Burners - Design of Burners. Gas Burners - Atmospheric Gas Burners - Air Aspiration Gas Burners - Burners Classification according to Flame Structures - Factors Affecting Burners & Combustion.

TOTAL: 45 PERIODS**8. Text Books**

1. Samir Sarkar, Fuels & Combustion, 3rd Edition, Orient Longman, 2010
2. Bhatt, Vora Stoichiometry, 6th Edition, Tata McGraw Hill, 2021
3. Blokh AG, Heat Transfer in Steam Boiler Furnace, Hemisphere Publishing Corpn, 1988.

9. References

1. Civil Davies, Calculations in Furnace Technology, Pergamon Press, Oxford, 1966
2. Sharma SP, Mohan Chander, Fuels & Combustion, Tata McGraw Hill, 1984.

COURSE CODE	COMPUTATIONAL FLUID DYNAMICS	L	T	P	C
10212ME115		3	0	0	3

1. Preamble

This course explains the evaluation of thermal problems and their possible solutions using computational methods. It enables the student to amalgamate their knowledge of fluid mechanics, mathematics, heat transfer, with computational techniques to solve problems.

2. Pre-requisite

10211ME208-Fluid mechanics and Machinery

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Explain about governing equations, discretization schemes, numerical methods, turbulence modeling, mesh quality and independence test, numerical errors, computational techniques and boundary conditions.
- Analyse various types of flow and their control methods for solving them.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Apply the boundary conditions to determine the mass, energy, and momentum of flowing fluid using partial differential equation.	K3
CO2	Solve 1D, 2D, and, 3D fluid flow problems using finite difference method.	K3
CO3	Solve the pressure viscous and boundary layer flow of incompressible fluid using SIMPLE, and PISO Algorithms	K3
CO4	Solve the steady state 1D and 2D convective heat transfer problems using finite volume method.	K3
CO5	Determine fluid flow and heat transfer using standard codes and turbulence models	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	L										H	H
CO2	H	H	L										H	H
CO3	H	H	L										H	H
CO4	H	H	L										H	H
CO5	H	H	L			H	H	H					H	H

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I GOVERNING DIFFERENTIAL EQUATION AND BOUNDARY CONDITIONS L-9

Basics of computational fluid dynamics – Governing equations– Continuity, Momentum and Energy equations – Chemical species transport –Physical boundary conditions – Time-averaged equations for Turbulent Flow – Turbulent–Kinetic Energy Equations- Error Minimization -Principles, Functional involving higher order derivatives, Essential and natural boundary conditions.

UNIT II DISCRETIZATION AND FINITE DIFFERENCE METHOD L-9

Computational Techniques: Definition, Methods – Finite difference, Finite volume and Finite element Methods. Discretization of steady State Problems: 1- D, 2 D and 3 D problems, Transient 1 D and 2 D problem, Basics and Implementation of boundary conditions. Solution procedure, solution criteria – stability and convergence, grid independent test, types of grid.

UNIT III INCOMPRESSIBLE FLUID FLOW L-9

Stream Function – Vorticity method, Creeping Flow, Staggered grid, Determination of pressure for viscous flow, SIMPLE algorithm and its variants – PISO Algorithms., Computation of Boundary layer flow, Introduction to upwind.

UNIT IV CONVECTION HEAT TRANSFER AND FEM L-9

Steady 1-D and 2-D Convection – diffusion, unsteady 1-D convection – diffusion. Numerical Methods for Radiation. Finite volume discretization of Convection-Diffusion Equations: Schemes. Introduction to finite element method – solution of steady heat conduction by FEM.

UNIT V TURBULENCE AND COMBUSTION MODELS L-9

Turbulence model: One equation and two equations models – advantages of RSM, DNS, LES models. Combustion model: Simple chemical reacting system model, Eddy break-up model and probability distribution function model. Prediction of fluid flow and heat transfer using standard codes.

TOTAL: 45 PERIODS

8. Text Books

1. Anderson, J. D., Computational Fluid Dynamics, McGraw Hill International, New York, 2017
2. Muralidhar, K., and Sundararajan, T., “Computational Fluid Flow and Heat Transfer”, Narosa Publishing House, New Delhi, 2nd Edition reprint 2014.

9. References

1. Suhas V, Patankar, “Numerical Heat transfer and Fluid flow”, Taylor & Francis, 2009.
2. Fletcher, C.A.J. “Computational Techniques for Fluid Dynamics 1 (Fundamental and General Techniques)”, Springer – Verlag, 2005.
3. Chung T.J, Computational Fluid Dynamics, Cambridge University Press, 2014.
4. Versteeg, H.K., and Malalasekera, W., “An Introduction to Computational Fluid Dynamics”: The finite volume Method, Pearson Education, 2014
5. Ghoshdastidar, P.S., “Computer Simulation of flow and heat transfer”, Tata McGraw Hill, 1998.

COURSE CODE	REFRIGERATION AND AIR CONDITIONING	L	T	P	C
10212ME116		3	0	0	3

1. Preamble

This course will be helpful for the students to enhance their knowledge in Refrigeration and Air Conditioning.

2. Pre-requisite

10211ME105-Applied Engineering Thermodynamics

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- About refrigeration and air conditioning cycles.
- Apply knowledge on various refrigeration cycles, system components and refrigerants to design refrigeration and air-conditioning systems.
- Factors which affect energy efficiency and total environmental warming impact.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Explain the working principle and estimate the performance of vapour compression and absorption systems.	K3
CO2	Describe the functions, types, properties and selection of refrigerant for refrigeration system.	K2
CO3	Determine the sensible heat factors on psychometric processes using psychometric chart.	K3
CO4	Estimate total cooling load and effective temperature for building cooling applications	K3
CO5	Explain the working principle of various air conditioning systems and design of air distribution systems.	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	M										H	
CO2	H	L					H						H	
CO3	H	H	M			H	H						H	
CO4	H	H	M				H						H	
CO5	H	L					H						H	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I REFRIGERATION SYSTEM & TYPES

L-9

Concepts of Thermodynamics & Heat Transfer- Review, Refrigeration- Definition & Need, Types of Refrigeration System- Vapour compression, Aircraft refrigeration, Steam jet refrigeration and Vapour absorption, Cycle analysis and Performance calculations.

UNIT II COMPONENTS OF REFRIGERATION SYSTEM & REFRIGERANTS

L-9

Essential Components of Theoretical Refrigeration System, Compressors – Types, Selection Criteria, Condensers - Types, Selection Criteria, Evaporators- Types, Selection Criteria, Expansion Valve- Types, Selection Criteria. Refrigerants–Nomenclature, Groups - Desired

Thermal, Chemical & Physical Properties – Selection of refrigerants based on property. Impact of refrigerants on Environment- ODP & GWP.

UNIT III PSYCHROMETRY

L-9

Fundamental properties of psychrometry – Use of psychrometric relations & psychrometric chart – Psychrometric processes – Grand and Room Sensible Heat Factors – By pass factor.

UNIT IV COOLING LOAD ESTIMATION

L-9

Heat transmission through & inside building- Solar radiation, Infiltration, Internal heat sources (sensible and latent), Outside air and fresh air load. Estimation of total load, Effective Temperature- Concept & Governing Factors, Comfort Chart.

UNIT V AIR CONDITIONING SYSTEM- CONCEPT & DESIGN

L-9

Air conditioning system – Concept, Need, Types & Applications, Requirements of comfort air conditioning. Duct design – Air distribution system, recommended design conditions and Ventilation standards.

TOTAL: 45 PERIODS

8. Text Books

1. Arora, S. C. and Domkundwar, S., A course in Refrigeration and Air conditioning, Dhanpat Rai (P) Ltd., New Delhi, 2018
2. Khurmi R.S., and Gupta, J. K., A text book of Refrigeration and Air Conditioning, Eurasia Publishing housing (P) Ltd, New Delhi, 2006.

9. References

1. Manohar Prasad, Refrigeration and Air conditioning, New Age International (P) Ltd, New Delhi, 3rd Edition (2021).
2. 2. Ashrae Hand Book', 4 Vol., Carrier Air Conditioning Co., 'Hand Book of Air Conditioning', Prentice Hall of India, 2021.

COURSE CODE	RENEWABLE SOURCES OF ENERGY	L	T	P	C
10212ME117		3	0	0	3

1. Preamble

This course helpful for the students to enhance their knowledge in renewable sources and empower the students to understand the need of renewable source, utilization of techniques and its advantages.

2. Pre-requisite

10210PH103-Applied Physics

10210CH101-Engineering Chemistry

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Describes the need of utilization of renewable resources
- Explains and provides knowledge on the solar, Wind, Geothermal and Ocean Energy resources and technologies
- Discusses the Direct energy conversion and its various forms.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describe the basic concepts of solar energy and thermal collector, and measurement of solar radiation.	K2
CO2	Explain the principle of photovoltaic energy conversion and thermal energy storage system.	K2
CO3	Illustrate the working principle and draw performance curves of wind energy conversion.	K3
CO4	Explain the principle of geothermal and various ocean energy conversion technologies.	K2
CO5	Explain the principle of different direct energy conversion technologies.	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H					H	H					H	
CO2	H	H	L				H	H					H	
CO3	H	H	L				H	H					H	
CO4	H	H	L				H	H					H	
CO5	H	H					H	H					H	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I PRINCIPLES OF SOLAR RADIATION

L-9

Introduction – Present Energy Scenario of Renewable Sources in Tamil Nadu, India and around the World. - The solar energy, Environmental impact of solar power, physics of the sun, the solar constant, extraterrestrial and terrestrial solar radiation, solar radiation on tilted surface, Instruments for measuring solar radiation and sun shine. Solar radiation data. Solar energy collection: Flat plate and concentrating collectors, classification of concentrating collectors.

UNIT II SOLAR ENERGY STORAGE AND APPLICATIONS**L-9**

Different methods, Sensible, latent heat and stratified storage, solar ponds. Solar Applications- solar heating/cooling technique, solar distillation and drying, photovoltaic energy conversion and components.; behavior of solar cells; cell properties; applications; grid connection; system design, RAPS applications.

UNIT III WIND ENERGY**L-9**

Sources and potentials, horizontal and vertical axis windmills, performance characteristics, interaction of wind and rotor; fatigue; process of electricity generation and wind farms. Data and Energy Estimation, Wind mill Applications, Performance Curves. Basics of wind Energy Conversion System, Basics of Wind Farm, Beltz Criteria Site Selection, Safety and Environmental Aspects.

UNIT IV GEOTHERMAL & OCEAN ENERGY**L-9**

Resources, types of wells, methods of harnessing the energy, potential in India. Ocean energy: OTEC, Principles utilization, setting of OTEC plants, thermodynamic cycles. Tidal and wave energy: Potential and conversion techniques, mini-hydel power plants, and their economics.

UNIT V DIRECT ENERGY CONVERSION**L-9**

Need for DEC, Carnot cycle, limitations, principles of DEC. Thermo-electric generators, seebeck, peltier and joul Thomson effects, Figure of merit, materials, applications, MHD generators, principles, dissociation and ionization, hall effect, magnetic flux, MHD accelerator, MHD Engine, power generation systems, electron gas dynamic conversion, economic aspects. Fuel cell Systems, faraday's law's, thermodynamic aspects, selection of fuels and operating conditions.

TOTAL: 45 PERIODS**8. Text Books**

1. D.P. Kothari, K.C. Singal, Rakesh Ranjan, Renewable Energy Sources and Emerging Technologies, Third Edition, PHI Learning, 2022.
2. Twidell, J.W. & Weir, A., "Renewable Energy Sources", EFN Spon Ltd., UK, 2006.
3. S.Rao, "Energy Technology", Khanna Publishers, New Delhi, 2005.
4. Boyle, G. Renewable energy, Power for a sustainable future. OxfordUniversity press, Oxford, UK, 2004.

9. References

1. Rajagopalan, R, "Environmental Studies-From Crisis to Cure", Oxford University Press, 2005.
2. Sukhatme. S.P., "Solar Energy", Tata McGraw Hill Publishing Company Ltd., New Delhi, 1997.
3. Cunningham, W.P. Cooper, T.H. Gorhani, "Environmental Encyclopedia", Jaico Publ., House, Mumbai, 2001.

COURSE CODE	GAS DYNAMICS AND JET PROPULSION	L	T	P	C
10212ME118		3	0	0	3

1. Preamble

This course will help the students understand the fundamentals of gas dynamics and jet propulsion.

2. Pre-requisite

10211ME104-Engineering Thermodynamics

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- To understand the theoretical concepts about compressible flow.
- To understand the isentropic flow with variable area
- To understand the flow in a constant area duct with friction
- To understand the flow in a constant area duct with heat transfer
- To understand the effects of normal and oblique shock wave on flow parameter
- To understand the construction, operation and performance of different types of aircrafts and rocket engines.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Compute static and stagnation properties of compressible fluid flow and isentropic flow on variable area ducts.	K3
CO2	Calculate the steep pressure rise on normal and oblique directions using Prandtl-Meyer, Rankine-Hugoniot equation and gas tables.	K3
CO3	Calculate friction flow and heat transfer effect on constant area ducts using Fanno flow and Rayleigh flow equations	K3
CO4	Illustrate the construction and operation of Turbo jet, Turbo-propeller, Pulse jet and Ramjet engines	K3
CO5	Illustrate the construction, operation of various types of rocket engines based on propellants	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	M				L						H	
CO2	H	H	M				L						H	
CO3	H	H	M				L						H	
CO4	H	H	M				H	H					H	L
CO5	H	H	M				H	H					H	L

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I BASIC CONCEPTS AND ISENTROPIC FLOWS

L-9

Properties of the Atmosphere - Basic concepts, Energy and momentum equations of compressible fluid flows- Various regions of flows - Reference velocities - Stagnation state – Mach wave and Mach cone - Effect of Mach number on compressibility. Isentropic flow with variable area - Nozzle and Diffuser- Types of wind tunnel- Use of gas tables.

UNIT II NORMAL AND OBLIQUE SHOCK WAVES

L-9

Normal shock wave - Governing equations - Variation of flow parameters across the normal shock – Prandtl-Meyer equation - Impossibility of a shock in subsonic flow – Supersonic wind tunnels - Flow with oblique shock waves (elementary treatment only).variation of flow parameters across the oblique shock wave - Rankine-Hugoniot equation – Use of gas tables.

UNIT III FLOW IN CONSTANT AREA DUCTS

L-9

Flow in constant area ducts with friction (Fanno flow) – Fanno curves and Fanno flow equation - Variation of flow properties and variation of Mach number with duct length - Isothermal flow with friction- Flow in constant area ducts with heat transfer (Rayleigh flow) - Rayleigh curves and Rayleigh flow equation - Variation of flow properties. Charts for Fanno and Rayleigh flows - Use of gas tables.

UNIT IV JET PROPULSION

L-9

Types of jet engines - construction and operating principle of Turbo jet, Turbo-prop, Pulse jet and Ramjet engines -Theory of jet propulsion - Energy flow through jet engines - Performance of turbo jet engines - Thrust augmentation.

UNIT V ROCKET PROPULSION

L-9

Types of rocket engines - Applications -Construction and operating principle of solid, liquid, hybrid and electrical rockets - Ignition and combustion - Theory of rocket propulsion - Performance study – flow through rocket nozzles - Solid and liquid propellants – Propellant feeding systems. Space flights.

TOTAL: 45 PERIODS

8. Text Books

1. S. M. Yahya., Fundamental of Compressible Flow, New Age International Pvt Ltd. New Delhi, 6th Edition (2018).

9. References

1. S. M. Yahya., Gas Tables for Compressible Flow, New Age International Pvt Ltd., New Delhi, 8th Edition (2018).
2. E. Rathakrishnan, Gas Dynamics, Prentice Hall of India, New Delhi, 5th Edition (2014).
3. Patrich.H. Oosthvizen, William E. Carscallen, Compressible fluid flow, Tata McGraw Hill Publishing Company Pvt Ltd., New Delhi, 2004
4. Cohen. H., R. E. C Rogers and Sravanamutoo, Gas Turbine Theory, Addison Wesley Ltd.
5. P. Balachandran, Fundamental of Compressible Fluid Dynamics, Prentice Hall of India, New Delhi, 2009.

COURSE CODE	AUTOMOBILE ENGINEERING	L	T	P	C
10212ME119		3	0	0	3

1. Preamble

This course provides an introduction to vehicle structure, engine, power transmission system, steering system, brakes and suspension, It also provides an introduction to engine emissions and their control and offers various alternative fuels that can be used in automobiles.

2. Pre-requisite

10211ME104-Engineering Thermodynamics

3. Link to the other courses

10211ME102-Machine Design

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- To identify and describe soft computing techniques and their roles in building intelligent machines.
- To recognize the feasibility of applying a soft computing methodology for a particular problem.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Explain the construction and working principle of internal combustion engines.	K2
CO2	Explain the operation of various engine auxiliary systems and battery.	K2
CO3	Describe the functions of transmission and cooling systems.	K2
CO4	Explain the working of steering, braking and suspension systems.	K2
CO5	Explain the methods of engine emission control and the requirement of alternative fuels.	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	L											M	
CO2	H	L											M	
CO3	H	L											M	
CO4	H	L											M	
CO5	H	L		H		L	H	L				L	M	L

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I VEHICLE STRUCTURE AND ENGINES

L-9

Introduction: General classification of automobiles, layout of chassis, types of drives of automobile. Chassis and body – Body parts, functions, material and vehicle construction. Engines – Types of Engines, components, functions and materials, working principle, comparison of four stroke and two stroke engines.

UNIT II ENGINE AUXILIARY SYSTEMS

L-9

Carburetor–types of carburetors-Working principle- Electronic fuel injection system – Mono-point and Multi - Point Injection Systems-direct and indirect injection – Battery, coil and

magneto ignition systems, electronic ignition systems. Construction, Operation and Maintenance of Lead Acid Battery, tall tubular batteries- principle and construction of starter motor, alternator, working of different starter drive units. Supercharging and Turbo charging.

UNIT III TRANSMISSION AND COOLING SYSTEMS

L-9

Clutch – Types and Construction – Gear Boxes, Manual and Automatic –Flywheel-Torque converters– Propeller shaft – Slip Joint – Universal Joints – Differential and Rear Axle – Hotchkiss Drive. Need for cooling system, Types of cooling system: air cooling system, liquid cooling system, forced circulation system, pressure cooling system. Introduction about automatic transmission systems.

UNIT IV VEHICLE CONTROL SYSTEMS

L-9

Wheels and Tyres - Steering Geometry – Power Steering – Types of Front Axle – Classification of brakes, drum brakes and disc brakes, constructional details, theory of braking, parking brake, braking material, hydraulic system, vacuum assisted system, air brake system, antilock braking system. Need of suspension system, types of suspension, suspension springs, constructional details and characteristics of leaf, coil and torsion bar springs, independent suspension, rubber suspension, pneumatic suspension, shock absorbers.

UNIT V EMISSION, EMISSION CONTROL AND ALTERNATIVE FUELS

L-9

Mechanism of HC, NO_x and CO formation in four stroke and two stroke SI & CI engines, smoke and particulate emissions in CI engines, NO_x formation and control. Noise pollution from automobiles, measurement and standards. Design of engine, optimum selection of operating variables for control of emissions, catalytic converters, catalysts. Fuel modifications -Use of Natural Gas, LPG, Biodiesel, Gasohol and Hydrogen in Automobiles - Electric and Hybrid Vehicles, Fuel Cells.

TOTAL: 45 PERIODS

8. Text Books

1. Ganesan, V., Internal Combustion Engines, Tata McGraw-Hill, New Delhi, 4th Edition 2017.
2. Kirpal Singh, Automobile Engineering- Vol. I and II, Standard Publishers, New Delhi, 13th Edition 2020.
3. Ramalingam. K .K, Automobile Engineering, Scitech publications, 2011.

9. References

1. Kamaraju Ramakrishna, Automobile Engineering, PHI Learning pvt. Ltd., New delhi- 2012.
2. Mathur M.L. and Sharma. 'A Course in Internal Combustion Engines', R.P. Dhanpat Rai Publications, 2009.
3. K. M. Gupta, Automobile Engineering- Vol I and II, Umesh Publications, 2007
4. G B S Narang, Automobile Engineering, Khanna publishers, New Delhi, 2005.

COURSE CODE	ADVANCED 3D MODELLING USING UNIGRAPHICS NX	L	T	P	C
10212ME201		2	0	2	3

1. Preamble

This course will cover fundamental concepts of 3D Modelling and Advanced tool techniques. It will endow students with abilities in designing, Assembling and Manufacturing based solutions for real-world and engineering problems.

2. Pre-requisite

10211ME301-Computer Aided Design and Drafting

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- To identify and describe advanced tool techniques and their roles in mechanical components.
- To recognize the feasibility of applying a unigraphics software for the particular problem.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Demonstrate the basic tools in the sketcher environment using GUI	K3
CO2	Draw 2D drawings using sketcher tools	K3
CO3	Use Boolean operations to develop 3D model of the given drawings.	K3
CO4	Use assembly constraints and tools to develop the assembly models of the given drawings.	K3
CO5	Generate 2D drawings and bill of materials for the given assembly.	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	H		H	M		M		L		H	H	H
CO2	H	H	H		H	M		M		L		H	H	H
CO3	H	H	H		H	M		M		L		H	H	H
CO4	H	H	H		H	M		M		L		H	H	H
CO5	H	H	H		H	M		M		L		H	H	H

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION TO UNIGRAPHICS

L-6 P-6

Introduction to Unigraphics NX, About NX Gateway, Getting Started, NX Graphical User Interface - Title bar, Menu bar, Toolbar, Radial toolbar, Selection bar, Cue and status line, Dialog rail, Resource bar, Navigators, HD3D tools, Integrated browser, Palettes, Roles, Full screen, View orientation- trimetric, isometric, View commands, Rotate, Pan, Zoom in/out, Quick pick, Quick pick, categories, Coordinate system- absolute coordinate system, WCS, Absolute coordinate, Work coordinate system. View triad, Multiple graphics window, Information window, Keyboard accelerators, Dialog box File management - Creating new files, Opening files and Saving files.

UNIT II SKETCHER**L-6 P-6**

Creating Sketches - Profile, Line, Arc, Circle, Fillet, Chamfer, Rectangle, Polygon, Studio pline, Fit spline, Ellipse, Conic Editing sketches - Quick trim, Quick extend, Make corner, Offset curve, Pattern curve, Mirror curve, Intersection point, Derived lines Constraints - Geometric constraints, Auto constraint, Inferred constraint, Dimensional constraints, Auto dimension, Animate dimension, Continuous auto dimension. Basic terminologies - Feature, Body, Solid body, Sheet, Face, Section curves, Guide curves. Creating Primitives - Block, Cylinder, Cone, Sphere, Boss, Pocket, Emboss, Slot, Groove. Feature modeling commands-Creating Extrude features, Creating Revolve features.

UNIT III PART MODELING**L-6 P-6**

Datums - Creating Datum planes, Axis, Point. Creating Sweep Features-Swept, Sweep along guide, variable sweep, Creating Tube feature Hole - General hole, Drill size holes, Screw clearance holes, Threaded holes Dart, Thread, Shell, Draft, Draft body, Scale Creating Blend and Chamfer. Instance feature - Rectangular array, Circular array, Pattern face, Mirror feature, Mirror body Feature Operations -To Divide face, Trim body, Split body, Boolean commands, User defined feature, Creating Feature group, Layer settings, To measure distance between geometries, To measure angle between geometries, To measure bodies and face geometries, To find geometric properties.

UNIT IV ASSEMBLY**L-6 P-6**

Introduction to Assembly Modeling, Assembly approaches Assembly constraints - Angle, Bond, Centre, Concentric, Distance, Fit, Parallel, Perpendicular, Touch align Component array - Linear array, Circular array, Feature instance array Moving a component, Replacing component, Repositioning component, Mirroring assembly. Creating a New Component, Creating a new parent, Assembly clearance, creating exploded views, Assembly sequencing with motion.

UNIT V DRAFTING AND DETAILING**L-6 P-6**

Creating the Sheets and Editing the Sheets, Standard settings. Creating drawing views- Base view, Drawing view, projected view. Section view- Simple section, Stepped section, Half section, Revolved section, Folded section, Unfolded section, Pictorial section, Half pictorial section, Break out section Detail view Creating Broken view Applying dimensions- Inferred Dimension, Horizontal Dimension, Vertical Dimension, Parallel Dimension, Perpendicular dimension, Angular dimension, Cylindrical Dimension, Hole dimension, Diameter Dimension, Chamfer Dimension, Radius or Radius of Curvature Dimension, Radius to Centre, Folded Radius, Thickness Dimension, Arc Length, Horizontal Chain Dimension, Vertical Chain Dimension, Horizontal Baseline Dimension, Vertical Baseline Dimension, Ordinate Dimension. Creating Annotations, Datum feature, symbols, feature control frame, placing datum target symbol. Creating the Centerline, Axis, Hatch and fill options Creating Table and Part list.

TOTAL: 60 PERIODS**8. Text Books**

1. NX 10 for Engineering Design, Ming C. Leu, Missouri University Of Science and Technology.
2. Siemens NX 10 Surface Design: A Step by Step Guide April 2016, Jaecheol Koh, CreateSpace Independent Publishing Platform, U.S.A.

9. References

1. Chris McMahon and Jimmie Browne "CAD/CAM Principles, practice and manufacturing management "Pearson education Asia, 2001.
2. https://web.mst.edu/~mleu/nx_manuals/nx10.pdf

COURSE CODE	FINITE ELEMENT MODELLING OF COMPOSITE STRUCTURES	L	T	P	C
10212ME120		3	0	0	3

1. Preamble

The intention of this course is to bridge the two subjects such as finite element methods and composite materials as a single unified content and make the students to have a theoretical and practical understanding on the finite element modelling of composite structures.

2. Pre-requisite

10211ME202-Strength of Materials

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Possess the basic knowledge in finite element methods, linear elasticity, composite materials and mechanics in the areas of applied engineering.
- Develop the skills in the areas of application of finite element techniques to solve lightweight engineering based product design problems.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Explain the use of linear algebra and linear elasticity for finite element modeling	K2
CO2	Describe the elastic behavior of lamina and laminates	K2
CO3	Apply Energy principles, and Rayleigh-Ritz method to solve static and dynamic problems	K3
CO4	Apply Finite element techniques to model the composite structures	K3
CO5	Apply CAE tools for composite structural analysis	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M											H	
CO2	H	M											H	
CO3	H	H	M										H	H
CO4	H	H	M										H	H
CO5	H	H	M		H	M	L	M		M		M	H	H

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION

L-5

Linear algebra - vector and matrix operations - Introduction to indicial notations and tensors - Review of linear elasticity equations.

UNIT II MECHANICS OF COMPOSITE MATERIALS

L-10

Introduction to composite materials - General characteristics - Elastic behavior of composite lamina at micro and macro level - Strength of unidirectional lamina at micro and macro level – Elastic behavior of multi-directional laminates - Failure prediction.

UNIT III FINITE ELEMENT METHODS**L-10**

Introduction - Concepts of FEM – Energy principles – Rayleigh –Ritz method of functional approximation - Stiffness matrix and shape functions for simple 1D and 2D elements – Convergent and compatibility requirement - Isoparametric formulation - Numerical integration - Finite element solution procedures for static and dynamic problems.

UNIT IV FE MODELLING OF COMPOSITE STRUCTURES**L-10**

Elements used for composite laminate analysis - Effect of change in mesh density - Accuracy of finite element solution - Modelling of composite materials - Other modelling methodologies applicable to composite materials - Composite structural optimization - effect of ply lay up on the structural response.

UNIT V CASE STUDIES**L-10**

Case studies and practical examples in composite structural analysis using CATIA, Hyper Mesh and LSDYNA

TOTAL: 45 PERIODS**8. Text Books**

1. J.N. Reddy, "Mechanics of Laminated Composite Plates and Shells: Theory and Analysis", CRC Press, 1997
2. F.L. Mathews, G.A.O. Davies, D. Hitchings, C. Soutis, "Finite Element Modelling of Composite Materials and Structures", Woodhead Publishing and CRC Press, 2003.

9. References

1. S.P. Timoshenko, J.N. Goodier, "Theory of Elasticity", McGraw Hill Education Pvt Ltd, 2013.
2. Roman Solecki, R, Jay Conat, "Advanced Mechanics of Materials", Oxford University Press, 2003.
3. R.M. Jones, "Mechanics of Composite Materials", Taylor and Francis, 1999.
4. I. Daniel, O. Ishai, "Engineering Mechanics of Composite Materials", Oxford University Press, 2006.
5. K.J. Bathe, "Finite Element Procedures", Eastern Economy Edition, PHI, 1996

COURSE CODE	INTEGRATED PRODUCT DESIGN AND PROCESS DEVELOPMENT	L	T	P	C
10212ME121		3	0	0	3

1. Preamble

This course is designed to provide knowledge about the concepts of various tools and approaches available for product design and process development.

2. Pre-requisite

11210ME101-Design Thinking

3. Link to the other courses

10212ME133-Total Quality Management
Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the concepts of tools and techniques in the Integrated Product Development area of the Engineering Services industry.
- Relate the engineering topics into real-world engineering applications.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Summarize the methodologies of product development	K2
CO2	Identify and explain the requirements to create new product design and optimization	K2
CO3	Compare different techniques involved in product design creation and testing	K3
CO4	Describe the methods of model creation and integration of software and hardware	K2
CO5	Estimate the manufacturing cost of products through economic considerations	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	L											H	
CO2	H	L											H	
CO3	H	L											H	
CO4	H	L											H	
CO5	H	H						L			M		H	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION

L-9

Global Trends Analysis and Product decision: Types of various trends affecting product decision - Social Trends-Technical Trends- Economic Trends- Environmental Trends- Political/ Policy Trends- PESTLE Analysis. Introduction to Product Development Methodologies and Management: Overview of Products and Services- Types of Product Development- Overview of Product Development methodologies - Product Life Cycle - Product Development Planning and Management.

UNIT II REQUIREMENTS AND SYSTEM DESIGN**L-9**

Requirement Engineering: Types of Requirements- Requirement Engineering- Analysis - Traceability Matrix and Analysis- Requirement Management. System Design & Modeling: Introduction to System Modeling- introduction to System Optimization- System Specification- Sub-System Design- Interface Design.

UNIT III DESIGN AND TESTING**L-9**

Conceptualization -Industrial Design and User Interface Design- Introduction to Concept generation Techniques-Concept Screening & Evaluation- Concept Design- S/W Architecture- Hardware Schematics and simulation-Detailed Design: Component Design and Verification- High Level Design/Low Level Design of S/W Programs- S/W Testing-Hardware Schematic- Component design- Layout and Hardware Testing.

UNIT IV IMPLEMENTATION, INTEGRATION & BUSINESS DYNAMICS**L-9**

Prototyping: Types of Prototypes -Introduction to Rapid Prototyping and Rapid Manufacturing. System Integration- Testing- Certification and Documentation: Introduction to Manufacturing /Purchase and Assembly of Systems- Integration of Mechanical, Embedded and S/W systems- Introduction to Product verification and validation processes - Product Testing standards, Certification and Documentation, Intellectual Property Rights and Confidentiality- Security and configuration management.

UNIT V DESIGN FOR MANUFACTURING AND PRODUCT DEVELOPMENT L-9

Definition - Estimation of Manufacturing cost-reducing the component costs and assembly costs – Minimize system complexity-Economic Analysis - Understanding and representing tasks-baseline project planning - accelerating the project-project execution.

TOTAL: 45 PERIODS**8. Text Books**

1. NASSCOM student Handbook "Foundation Skills in Integrated Product Development".
2. Product Design and Development, Karl T.Ulrich and Steven D.Eppinger, McGraw –Hill International Edns.1999
3. Anita Goyal, Karl T Ulrich, Steven D Eppinger, "Product Design and Development ", 4th Edition, 2009, Tata McGraw-Hill Education, ISBN-10-007-14679-9

9. References

1. George E.Dieter, Linda C.Schmidt, "Engineering Design", McGraw-Hill International Edition, 4th Edition, 2009, ISBN 978-007-127189-9
2. Kevin Otto, Kristin Wood, "Product Design", Indian Reprint 2004, Pearson Education,ISBN. 9788177588217
3. Yousef Haik, T. M. M. Shahin, "Engineering Design Process", 2nd Edition Reprint, Cengage Learning, 2010, ISBN 0495668141.

COURSE CODE	FINITE ELEMENT ANALYSIS OF MECHANICAL	L	T	P	C
10212ME202	SYSTEMS	2	0	2	3

1. Preamble

This course imparts the knowledge to understand fundamental concepts of finite element analysis and its tools in a generic framework and provide clear understanding of FEA Analysis for Engineering Applications.

2. Pre-requisite

10211ME203-Finite Element Analysis

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Prepare drawings for various mechanical components using any commercially available 3D modeling software's
- Develop a thorough understanding of the Computer Aided Finite Element Analysis packages with an ability to effectively use the tools of the analysis for solving practical problems arising in engineering design.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Solve linear and non-linear problems using FEA tool	K3
CO2	Generate key points, Lines, Surfaces and Solids using FEA workbench	K3
CO3	Analyze 3D geometry interface check using FEA tools	K4
CO4	Demonstrate 2D and 3D analysis of structural components	K3
CO5	Demonstrate 2D and 3D analysis for thermal applications	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	M		M							M	H	H
CO2	H	H	M		M							M	H	H
CO3	H	H	M		M							M	H	H
CO4	H	H	M		M							M	H	H
CO5	H	H	M		M							M	H	H

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION TO FEA

L-6 P- 6

Basics of various engineering topics like Static, Quasi Static, Dynamic, Linear & Non-Linear Engineering Problems, Types of Non Linearities, Rigid Body Dynamics, Multi Body Dynamics Basics, Finite Element Methods (FEM) & Finite Element Analysis (FEA)

Experiments: Common Steps to solve engineering problems using FEA.

UNIT II FINITE ELEMENT ANALYSIS WORK BENCH

L-6 P- 6

Fundamentals of FEA Software Package, Design Modeller in Workbench.

Experiments: Key points, Lines, Surfaces and Solids.

UNIT III GEOMETRIC MODELING

L-6 P- 6

Geometry Import from any CAD software, File Management, Geometric Modeling Tools using work bench, geometry parameter validation

Experiments: Importing CAD Drawings, interface check, Geometry view

UNIT IV MESHING

L-6 P- 6

1D & 2D Meshing using Work Bench with ALL Element Types, 3D Meshing using Work Bench with ALL Element Types, Element Quality Check against set criteria and Refining Mesh Quality, Auto meshing and Manual Meshing Tools Lab Exercises, Assigning Material Properties, Constraints, Loads

Experiments: 2D and 3D Analysis of Structural Components, Grid independence study.

UNIT V SOLVER

L-6 P- 6

Structural Static Linear & Non-Linear Analysis using Work Bench, Structural Dynamics Analysis (Modal Analysis & Transient),

Experiments: Thermal Analysis, Results review & preparation of Analysis Reports. (Post Processing), Analysis Report Preparation.

TOTAL: 60 PERIODS

8. Text Books

1. David V.Hutton, "Fundamentals of Finite Element Analysis", Tata McGraw-Hill Edition, 2014.

9. References

1. Huei-Huang Lee "Finite Element Simulations with ANSYS Workbench 17 "SDC Publications, 2018.

COURSE CODE	SURFACE MODELLING AND ASSEMBLY	L	T	P	C
10212ME203		2	0	2	3

1. Preamble

This course imparts the knowledge to understand fundamental concepts of surface modelling and its tools in a generic framework and provide clear understanding of CAD systems for 3D modeling and assembly.

2. Pre-requisite

10210ME201-Engineering Graphics

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the various stages in the design process and the role of computer graphic communication process.
- Understand the concepts of Part Design and Surface design for modeling of mechanical components.
- Familiarize with the computer applications in design and preparing drawings for various mechanical components.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describe the basics of Surface Modelling, Parametric technology	K2
CO2	Describe the use of Part modelling and Editing Modules	K2
CO3	Demonstrate the applications of Surface Design	K3
CO4	Analyze the Assembly Design by CAD modules	K4
CO5	Utilize the CAD Modules in 3D modelling & Assembly	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	M		M							M	M	H
CO2	H	H	M		M							M	M	H
CO3	H	H	M		M							M	M	H
CO4	H	H	M		M							M	M	H
CO5	H	H	M		M							M	M	H

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION TO SURFACE MODELLING

L-6 P-6

CAD/CAM/CAE Product cycle, Parametric Technology, Introduction to CAD Environment & Menu bar and Use of Mouse.

Sketcher: Workbench creating 2D Geometry, Working on Profile Toolbar Dimensioning the Sketches, Modifying and Constructing using Operation & Transformation Toolbar.

Experiments: Applying Constraints & Constraint Definition, Animating constraint & Checking Various Mechanisms.

UNIT II PART DESIGN

L-6 P-6

Understanding Part Design Environment, Creating Solid Models using Sketch-Based Features, Working with Dress-Up Features, View Toolbar, Creating & Working efficiently on Reference Elements Planes and lines & points.

Editing: Updating Features, Transformation Features e.g. Patterning, Rotating, Advanced Modeling Techniques

Experiments: Boolean Operations, Annotations, Assigning Materials & Measuring Properties.

UNIT III SURFACE DESIGN

L-6 P-6

Creating Wireframe elements - helix, splines, Curves, etc. Creating Surfaces like blended, lofted surfaces, etc. Operations on Shape Geometry

Experiments: Joining, splitting & trimming.

UNIT IV ASSEMBLY DESIGN

L-6 P-6

Creating Bottom-up Assemblies, Inserting Components, Using Smart Move tool, Applying Constraints, Creating Top-down Assemblies, Working with Subassemblies, Editing Assemblies, Simplifying Assembly, Interference Detection, Sectioning & exploding assembly.

Experiments: Shaft couplings – Plummer block – Screw jack- Lathe Tailstock – Universal Joint – Machine Vice – Stuffing box- safety Valves - Non-return valves.

UNIT V DRAFTING WORKBENCH

L-6 P-6

Generating Drawing View with 1st angle or 3rd angle, Using Wizard, Generating Projected, Auxiliary, Section, Detailed views, etc. Using Control knob, Editing Views, Generating Dimensions, Inserting Sheets, Adding Datum, Geometric Tolerances & symbols and Generating BOM table.

Experiments: Connecting rod –Piston and crank shaft- Multi plate clutch- Preparation of Bill of materials and tolerance data sheet

TOTAL: 60 PERIODS

8. Text Books

1. Ibrahim Zeid “CAD/CAM -- Theory and Practice” 2nd Edition- McGraw Hill, International Edition, 2012.
2. Sham Tickoo, CATIA V5R20 for Designers, Tickoo CAD/CIM Series, 2017.

9. References

1. Chris McMahon and Jimmie Browne “CAD/CAM Principles, practice and manufacturing management” Pearson education Asia, 2001.

COURSE CODE	METAL CASTING TECHNOLOGY	L	T	P	C
10212ME122		3	0	0	3

1. Preamble

This course will help the students understand the advanced metal casting techniques and their applications.

2. Pre-requisite

10211ME204-Manufacturing Technology

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- To understand the basic principles of metal casting
- To know the various types of melting practices
- To broaden the understanding of casting design principles
- To know about casting defects and remedial measures

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describe the construction, types, and materials for core and mould making processes.	K2
CO2	Describe the procedure to select oil fired, electric, and cupola furnaces for melting different materials	K2
CO3	Explain the construction, types, and functions of special casting process.	K2
CO4	Describe solidification and selection procedure for casting design using simulation software.	K3
CO5	Outline the causes and inspection methods of casting defects and quality control systems.	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M						L					H	
CO2	H	M						L					H	
CO3	H	M					L						H	
CO4	H	M			M	M	L					L	H	H
CO5	H	M					L					L	H	H

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I MOULDING PRACTICES

L-9

Rotational moulding- compression moulding- Moulding machines and core making machines. Different types of cores- Core making processes- Materials for core making- Recent developments in core mould making- Cold set process- Pattern design- materials and construction.

UNIT II MELTING PRACTICES**L-9**

Foundry furnaces - Selection of furnaces - Crucibles oil fired furnaces - Electric furnaces - Cupola furnace, material handling in casting process- melting practice for cast iron, aluminum alloys, copper alloys and magnesium alloys- - fluxing, degassing.-safety considerations.

UNIT III RECENT TRENDS IN CASTING**L-9**

Permanent mould casting - Precision investment casting - continuous casting - Squeeze casting – Electro slag casting - Near Net Techniques. Introduction to Rapid prototyping – Stir casting- applications in casting process.

UNIT IV CASTING DESIGN**L-9**

Concept of solidification, directional solidification, role of chilling, Casting design -principles of gating- functions of riser, types of riser, bottom pouring and top pouring. Introduction to Design considerations for Castings, Casting design softwares- Introduction to metal casting simulation.

UNIT V CASTING DEFECTS AND QUALITY CONTROL**L-9**

Causes and prevention of defects in castings and - inspection of castings- Quality control and quality assurances, Non Destructive testing – Dye penetrant – magnetic particle – X-ray, ultrasonic-Statistical quality control in foundry.

TOTAL: 45 PERIODS**8. Text Books**

1. Richard W Heine, 2003, Principles of Metal Casting, Tata McGraw Hill Education Private Limited, Park ohio USA,
2. Ramana Rao T. V, Metal Casting: Principles and Practice, New Age International, 2010

9. References

1. Metal Casting Principles and Techniques,Yury . S. Lerner, Nageswara Rao Posinasetti,American Foundry Society,December 2013.
2. Foundry Technology,Peter R. Beeley,Butterworth-Heinemann, 2001 - Technology & Engineering
3. Jain, P.L., "Principles of Foundry Technology", 4th Edition, Tata McGraw Hill Pub., Co. Ltd., 2008.
4. Heine, R.W.,Carl Loper, and Rosenthal, P.C., "Principles of Metal Casting", 2nd Edition, Tata McGraw Hill Pub. Co. Ltd., 2008

COURSE CODE	ADVANCED METAL FORMING PROCESSES	L	T	P	C
10212ME123		3	0	0	3

1. Preamble

This course addresses metal forming principles, the issues in forming, analysis and the methods of overcoming them during real time application.

2. Pre-requisite

10211ME204-Manufacturing Technology

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Know the principles, methods, areas of applications, possibilities and limitations as well as environmental effects of the various metal forming processes
- Be familiar with the different tests and methods of controlling friction during the metal forming processes.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Classify hot and cold working processes and its effect on mechanical properties	K3
CO2	Explain the impact of interfacial friction in metal forming processes	K2
CO3	Explain the principles of tribo-tests to quantify interfacial friction	K2
CO4	Classify sheet metal forming and extrusion processes and associated defects	K3
CO5	Describe different types of special forming processes and its applications	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H											H	
CO2	H	H											H	
CO3	H	H											H	
CO	H	H											H	
CO5	H	H											H	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION TO METAL FORMING PROCESSES

L-9

Classification of metal forming processes - Advantages, disadvantages and Limitations – stress-strain relations in elastic and plastic deformation. Concepts of true stress, true strain, triaxle and biaxial stresses. Hot and cold working processes and effect on mechanical properties.

UNIT II FORGING AND PARAMETERS OF METAL FORMING

L-9

Classification of forging process. Forging machine equipment – Expressions for forging pressures & load within open and closed die forging by slab analysis. Material flow lines in forging – forging defects- residual stresses in forging. Metallurgical aspects of metal forming –

slip and twinning, effect of temperature, impact of strain rate in forming processes, interfacial friction and – various lubricants used in forming processes.

UNIT III ROLLING AND DRAWING

L-9

Rolling classification – rolling mills – rolling of bars and shapes – rolling forces – analysis of rolling – defects in rolling – theories of hot and cold rolling – torque power estimation. Drawing classification – rod and wire drawing equipment – analysis. Deep drawing – tube drawing – analysis, residual stresses.

UNIT IV SHEET METAL AND EXTRUSION

L-9

Formability studies – Conventional processes – HERF Techniques – Superplastic forming techniques – Hydro forming – Stretch Forming – water hammer forming – magnetic pulse forming - principles and process parameters – advantage, limitations and application – forming limit criteria – defects.

Extrusion: Classification of extrusion processes, extrusion equipment. Hot extrusion. Deformation and defects in extrusion. Analysis of the extrusion process. Cold extrusion. Extrusion of tubing and production of seamless pipe and tubing.

UNIT V POWDER METALLURGY AND SPECIAL FORMING PROCESS

L-9

Overview of P/M technique – Advantages – applications – Powder preform forging – powder rolling – Tooling, process parameters and applications. - Orbital forging – Isothermal forging – Hot and cold isostatic pressing – High speed extrusion – Rubber pad forming – Fine blanking – LASER beam forming.

TOTAL: 45 PERIODS

8. Text Books

1. Altan T., Metal forming – Fundamentals and applications – American Society of Metals, Metals park, 2003.
2. Dieter G.E., Mechanical Metallurgy (Revised Edition II) McGraw Hill Co., 2004
3. Avitzur, "Metal Forming Processes and Analysis ", Tata McGraw - Hill, 2005.
4. Metal Forming: Mechanics and Metallurgy by William F. Hosford and Robert M. Caddel (4th edition), Cambridge University Press.
5. Narayanasamy R., "Theory of Plasticity", Ahuja Publications, 2000
6. P.N. Rao, "Manufacturing Technology: Foundry, Forming and Welding", McGraw Hills, New York, 4e (Volume 1) 2013.

9. References

1. ASM Handbook Vol. 14
2. Serope Kalpajian, Steven R.Schmid, "Manufacturing Processes for Engineering Materials", 4/e, Pearson Education, Inc. 2007.
3. Taylon Altan, "Cold and Hot Forging, Fundamentals and Applications", ASM International, the Materials Information Society, Ohio, 2005.

COURSE CODE	ADVANCED METAL JOINING PROCESSES	L	T	P	C
10212ME124		3	0	0	3

1. Preamble

This course provides an insight on metal joining processes made using conventional and non-conventional techniques. It also throws light on the essentials of metal joining that includes knowledge on welding symbols, types of joints, specifications, joint quality, equipment, accessories and safety precautions.

2. Pre-requisite

10211ME204-Manufacturing Technology

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- To understand the various metal joining processes, characteristics of weldable metals, safety precaution and automation in metal joining.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describe the fundamentals of metal joining equipment, accessories, and treatment processes	K2
CO2	Illustrate the principles, working and applications of various fusion joining techniques	K3
CO3	Illustrate the construction and working of various solid state joining techniques	K3
CO4	Explain the mechanical and metallurgical characteristics of metals, and testing of joints at weld zone	K2
CO5	Explain the automation process in welding and safety procedures	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M											M	
CO2	H	M											M	
CO3	H	M											M	
CO4	H	M											M	
CO5	H	M											M	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I FUNDAMENTALS OF METAL JOINING

L-9

History of metal joining – Classifications – Applications – Welding equipment and accessories – Pretreatment and post treatment - different types of weld joints– Welding symbols.

UNIT II FUSION JOINING PROCESSES

L-9

Soldering: tools, types of tips, solderability, procedure, desoldering – Arc welding: principle, welding machine (AC vs DC), Significance of polarity – Electrodes: types, constituents, functions, specifications – Brazing: types, selection of fillers, fuels and flames, flux, atmosphere – Forge welding: principle, working, advantages, disadvantages, applications –

Explosive welding: principle, working, advantages, disadvantages, applications.

UNIT III SOLID STATE JOINING PROCESSES

L-9

Adhesive bonding – Riveting - Diffusion bonding – Friction Welding – Friction Stir Welding - Friction Stir Spot Welding – Linear Friction Welding - Magnetic Welding - Resistance welding.

UNIT IV CHARACTERISTICS OF METAL, WELD ZONES AND JOINT L-9 **QUALITY**

Properties of metal: physical, chemical and mechanical – Selection of metals and alloys: functional, manufacturing and economical – Factors affecting weld quality – Testing of joint quality – Weld zones.

UNIT V WELDING AUTOMATION AND SAFETY

L-9

Introduction to welding automation – Advantages and disadvantages – TANDEM MIG – Robotic welding – Narrow gap SAW – Laser arc hybrid welding - Electron beam welding. Need for safety during metal joining – Safety standards – Precautions – Safety equipment for metal joining – Case study on welding accidents.

TOTAL: 45 PERIODS

8. Text Books

1. O.P. Khanna" A Text Book of Welding Technology", Dhanpat Rai Publishing Co. Pvt. Ltd. , New Delhi, India. 2018.
2. S.P. Tewari, S.A. Rizwi" Advanced Welding Technology", S.K. Kataria and Sons Publishers, 2013.

9. References

1. Mahmoud Kamel Semaary, Ibrahiem Mause" Principles of Applied Welding Technology", LAP Lambert Academic Publishing, 2011.
2. M.J.M Hermans" Welding Technology", ebook, Boeken Bestsellers.NL.
3. R.S. Mishraa,, Z.Y. Ma (2005) Friction stir welding and processing, Materials Science and Engineering R 50 pp.1–78.

COURSE CODE	IoT IN MANUFACTURING	L	T	P	C
10212ME125		3	0	0	3

1. Preamble

The course is prepared to provide the detailed understating of IoT in manufacturing

2. Pre-requisite

10211ME207-Mechatronics

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Discover key IoT concepts including identification, sensors, localization, wireless protocols, data storage and security
- Explore IoT technologies, architectures, standards, and regulation
- Realize the value created by collecting, communicating, coordinating, and leveraging the data from connected devices
- Examine technological developments that will likely shape the industrial landscape in the future
- Understand how to develop and implement own IoT technologies, solutions, and applications.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Illustrate the understanding of the basic concept of industry 4.0	K2
CO2	Explain the application of various technology in industry 4.0	K2
CO3	Describe the implementation of various production philosophies in industry 4.0	K2
CO4	Explain the method of analysis of various processes to implement the industry 4.0	K2
CO5	Apply the concepts of IoT in manufacturing Sectors	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L											H	
CO2	M	L											H	
CO3	M	L											H	L
CO4	M	L											H	L
CO5	H	H	M		L								H	H

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION OF INDUSTRY 4.0

L-9

Introduction to First, second and third industrial revolution, challenges in third revolution, Opportunity and challenges in Industry 4.0 characteristic of industry 4.0, Industry 4.0 environment.

UNIT II TECHNOLOGIES IN INDUSTRY 4.0

L-9

The vision of ubiquitous Computing, Cyber physical system, Internet of Things and Service

(IoT), Intelligent object, Intelligent system, Automatic identification and localization, Machine to Machine communication, Sensing and actuating, Data and information processing, Human machine interaction, Artificial Intelligence, Autonomy of action, Digital integration platform.

UNIT III SENSOR, ACTUATORS AND CONNECTIVITY IN INDUSTRY 4.0 L-9

Definition, Classification, Principle, Selection Criteria, Signal Conditioning, Calibration, Static and Dynamic characteristics, Introduction of communication protocols i.e. IEEE 802.15.4, Zigbee, 6LoWPAN, Wireless HART, Z-Wave, ISA-100, Bluetooth, NFC, RFID.

UNIT IV PRODUCTION SYSTEMS IN INDUSTRY 4.0 L-9

Sustainability assessment of manufacturing, Lean Production system, Just in Time production system, Agile Manufacturing, Smart and Business perspective, collaboration platform and product life cycle.

UNIT V IIoT APPLICATIONS L-9

Machining, Casting, and Fabrication industries, Factories and assembly line, Food industry, Healthcare, Power plant, Production planning and control, Inventory management and quality control, Plant security and safety, facility management.

TOTAL: 45 PERIODS

8. Text Books

1. Introduction to Industrial Internet of Things and Industry 4.0, Sudip Misra, Chandana Roy and Anandarup Mukherjee, CRC Press, Dec 2020.

9. References

1. Bahga and V. Madiseti, Internet of Things, A hands-on approach, CreateSpace Independent Publishing Platform, 1st edition, 2014, ISBN: 978-09960255
2. D. Boswarthick, O. Elloumi, and O. Hersent, M2M communications: A systems approach, Wiley, 1st edition, 2012, ISBN: 978-1119994756
3. K. Laudon and J. Laudon, Management Information Systems, 14th edition, Pearson Higher Education, 2016, ISBN: 9780136093688.

COURSE CODE	MICROMACHINING AND MANUFACTURING	L	T	P	C
10212ME126		3	0	0	3

1. Preamble

This course provides an overview to the basic concepts and techniques of micro manufacturing, manufacturing methods, micro finishing process and Nano fabrication.

2. Pre-requisite

10211ME205-Machining and Machine Tools Technology

3. Link to the other courses

Non Traditional machining processes

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the principles of various micro manufacturing methods.
- Explain the processes used for micro finishing.
- Acquire knowledge on hybrid fabrication techniques.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Explain the need of miniaturization and classify different approaches of micro manufacturing	K2
CO2	Explain material removal mechanism and types of micro machining operations	K2
CO3	Explain the different types of unconventional machining processes employed for micro machining	K2
CO4	Classify types of micro finishing processes and its application	K3
CO5	Explain the types of nano machining techniques and its applications	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H					L						H	
CO2	H	H					L						H	
CO3	H	L					L						H	
CO4	H	L					L						H	
CO5	H	H					L						H	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION

L-9

Introduction to Meso, Micro and Nano manufacturing, Miniaturization and applications, classification-subtractive, additive, micro forming, micro casting, and micro joining. Applications of Micro products in IT and telecommunications, Automotive, Medicine.

UNIT II MANUFACTURING METHODS

L-9

Material deposition – PVD, CVD, LIGA, Traditional Micromachining-Theory of micromachining-Chip formation-size effect in micromachining, micro turning, micro drilling, micro milling, Diamond turn machining-material removal mechanism.

UNIT III ADVANCED MACHINING**L-9**

Introduction to mechanical and beam energy based micro machining processes- Ultrasonic micro machining, Focused Ion Beam machining, Laser Beam micro machining, Micro EDM

UNIT IV FINISHING PROCESSES**L-9**

Micro finishing processes- Abrasive Flow Machining, Magnetic Abrasive Finishing, Magneto Rheological Abrasive Flow Machining, Magneto Rheological Finishing. Hybrid micromachining – Electro Chemical Spark Micro Machining, Electro Discharge Grinding, Electrolytic in Process Dressing Grinding.

UNIT V NANO FABRICATION**L-9**

Nano machining techniques – Top/Bottom up Nano fabrication techniques - Sub micron lithographic technique, conventional film growth technique, Chemical etching, Quantum dot fabrication techniques.

One day visit, to any relevant industry, is mandatory for the completion of this course.

TOTAL: 45 PERIODS**8. Text Books**

1. "INTRODUCTION TO MICROMACHINING", V.K.JAIN published by NAROSA publishers, New Delhi(2009)
2. "MICROMANUFACTURING PROCESSES", by V.K.JAIN, CRC Press.

9. References

1. Franssila. S., "INTRODUCTION TO MICRO FABRICATION", John Wiley and sons Ltd., UK, 2004, ISBN: 978-0-470-85106-7
2. Madore, J, "FUNDAMENTAL OF MICRO FABRICATION", CRC Press, 2002.
3. Jackson, M.J., "MICRO FABRICATION AND NANO MANUFACTURING", CRC Press, 2006.

COURSE CODE	NANOMATERIALS AND APPLICATIONS	L	T	P	C
10212ME127		3	0	0	3

1. Preamble

This course provides insight into the fundamental and basic principles of nano materials.

2. Pre-requisite

10211ME103-Materials and Metallurgy

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- To understand the fundamentals of nanomaterial strength and its mechanical behavior.
- To understand the analysis involved in zero dimensional, one dimensional nanostructured materials and characterization.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Enumerate types of nanomaterials and their comparisons with conventional materials.	K2
CO2	Describe the theory involved in zero dimensional nanomaterials	K2
CO3	Explain the principle analysis of one-dimensional nanomaterials.	K2
CO4	Describe the types, characteristics and applications of super hard coatings and nano structured materials.	K2
CO5	Illustrate the types, working and applications of nanomaterial characterization techniques	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M					L						H	L
CO2	H	M				L	L						H	L
CO3	H	M				L	L						H	L
CO4	H	M				L	L						H	L
CO5	H	M				L	L						H	L

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION TO NANOMATERIALS

L-9

Amorphous, Crystalline, microcrystalline, quasicrystalline and nanocrystalline materials- historical development of nanomaterials – Nanomaterials classification (Gleiter's Classification), Scientific basis for top-down and bottomup approaches to synthesize Nanomaterials – Properties changes done to size effects, Hall – petch, inverse Hall- petch effects - polymeric nanostructures.

UNIT II ZERO DIMENSIONAL NANOMATERIALS

L-9

Top-down processes: Mechanical alloying-Ball Milling, types of lithography; Bottom-up processes: i) Wet chemical synthesis of nanomaterials- sol-gel technique, ii) Gas phase synthesis of nanomaterials- Furnace, Flame assisted ultrasonic spray pyrolysis - Epitaxial

Techniques.

UNIT III ONE DIMENSIONAL NANOMATERIALS

L-9

Carbon nanotubes – Old and new forms of carbon – Structure of CNT and classification, Processing – Nanowire – processing – Laser ablation – Oxide assisted growth – carbothermal reactions – Thermal evaporation – Template based synthesis – Electro spinning – vapor – liquid – solid growth (VLS technique) – Applications.

UNIT IV SUPER HARD COATINGS AND BULK NANOSTRUCTURED MATERIALS

L-9

Super hard coating – types – characteristics – Chemical vapour deposition (CVD), Physical Vapour deposition(PVD) and their applications , sputtering, types of ion plating process, Bulk nanostructure formation – Equal Channel Angular pressing (ECAP) , Accumulative roll bending , Reciprocating extrusion.

UNIT V CHARACTERIZATION OF NANOMATERIALS

L-9

Scanning Electron Microscope (SEM) – Transmission Electron Microscope (TEM) - Scanning Tunneling Microscope (STM)- Atomic Force Microscope (AFM) – XRD, Infrared Spectroscopy- Energy Dispersive Analysis of X-rays (EDAX) - Nanoindentation – factors affecting Nano indentation.

TOTAL: 45 PERIODS

8. Text Books

1. Carl C. Koch (ed.), "Nanostructured Materials", Processing, Properties and Potential Applications, Noyes Publications, Norwich, New York, U.S.A.
2. Bhusan, Bharat (Ed), "Springer Handbook of Nanotechnology", 2nd Edition, 2007.

9. References

1. Mark Ratner and Daniel Ratner, "Nano Technology", Pearson Education, New Delhi, 2003.
2. Charles P. Poole Jr., Frank J. Ownes, 'Introduction to Nanotechnology', WileyInterscience, 2003.
3. G. Wilde, "Nanostructured Materials', Elsevier, 2008.
4. Bamberg, D., Grundman, M. and Ledentsov, N.N., "Quantum Dot Heterostructures", Wiley,1999.
5. G Timp (ed), "Nanotechnology", AIP press/Springer, 1999.
6. Kelsall Robert W, Ian Hamley and Mark Geoghegan, "Nanoscale Science and Technology", Wiley Eastern, 2004.
7. Michael Kohler, Wolfgang and Fritzsche, "Nanotechnology: Introduction to Nanostructuring Techniques", Wiley –VcH, 2004,
8. Dr.Sunita Singh, "Nano Science", Dhanpat Rai Ltd, new Delhi-32, 2012.

COURSE CODE	ARTIFICIAL INTELLIGENCE SYSTEM IN MANUFACTURING	L	T	P	C
10212ME128		3	0	0	3

1. Preamble

This course addresses practical experience with algorithms used in advanced manufacturing system (artificial intelligence - expert systems).

2. Pre-requisite

NIL

3. Link to the other courses

10212ME157 -Flexible Manufacturing Systems

4. Course Educational Objectives

Students, after undergoing this course would

- Familiarize students with new modern methods and tools used for design and control of manufacturing systems with respect to automated manufacturing.
- The emphasis is placed on methods based on application of knowledge base systems in modern manufacturing.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Explain the uses of Artificial intelligence in computer aided design	K2
CO2	Apply knowledge and network representation programming in an expert system.	K3
CO3	Apply machine learning and genetic algorithm in decision support systems	K3
CO4	Analyses performance of multilayer network	K4
CO5	Apply Fuzzy logic and neural networks to design an expert system	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H											H	
CO2	H	H	M										H	
CO3	H	H	M										H	
CO4	H	H	M										H	
CO5	H	H	H		M			M				M	H	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION

L-9

Artificial Intelligence in CAD, Applications of Artificial Intelligence in Design. Scope and History of AI. Structure of an Expert System, Building an Expert System. Strategies for Knowledge Acquisition, Components of Knowledge. Knowledge Representation, Production Systems, Decision Tables.

UNIT II KNOWLEDGE REPRESENTATIONS

L-9

Knowledge Representations Process, Purposes, Contexts and Agents, Knowledge Soup, Knowledge Acquisition and Sharing. Knowledge Representation Languages, Issues in Knowledge Representation. A Network Representation Language.

LISP: Introduction to LISP. Search Strategies in LISP

UNIT III DECISION SUPPORT SYSTEMS**L-9**

Introduction. Basis of Decision Making. Typical Progressive Models. Intelligent Models, Life-Cycle Values. Total Life-Cycle Cost.

Learning Processes and AI Algorithms: The General Problem Solver and Difference Tables. Machine Learning, Perceptron Learning, Back Propagation Learning.

The Genetic Algorithm: The Genetic Programming.

UNIT IV ARTIFICIAL NEURAL NETWORK**L-9**

Multi-layer Network: Back propagation, examples & applications, performance of multilayer feed forward Network.

UNIT V DESIGN OF EXPERT SYSTEMS AND APPLICATIONS**L-9**

Benefits and Examples of Expert Systems. Design of Expert Systems, Introduction to CLIPS, Pattern Matching, Modular Design and Execution Control Fuzzy Logic, Typical Expert System MYCIN, DENDRAL, PROSPECTOR.

TOTAL: 45 PERIODS**8. Text Books**

1. A guide to Expert Systems – Donald A Waterman, Addison Wesley, 1st edition, 2002.
2. Principles of Artificial Intelligence – Springer-Verlag, Berlin, paperback edition, 1982.

9. References

1. Understanding Decision Support System and Expert Systems – McGraw Hill, 2nd edition, 1993. Artificial Intelligence – Elaine Rich, McGraw Hill, 3rd edition, 2010.

COURSE CODE	ENGINEERING APPLICATIONS OF PUMP	L	T	P	C
10212ME129		3	0	0	3

1. Preamble

To deepen the knowledge on selection, commissioning, and testing of pumps based on their performance characteristics for various applications.

2. Pre-requisite

10211ME208-Fluid Mechanics and Machinery

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- To provide an overview of flow through pipes and the various losses.
- To familiarize the performance characteristics of different roto dynamic pumps under various operating conditions.
- To select the pumps according to the need of customers and suggesting a procedure for installation and commissioning.
- To disseminate the various testing procedures for pumps according to the purpose of usage.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Determine the minor and major losses in flow through pipes	K3
CO2	Draw and analyze characteristic curves of axial, radial, and mixed flow pumps	K3
CO3	Illustrate the selection procedure and the installation of pumps for the given specifications	K3
CO4	Illustrate the types, principle, and testing methods of rotodynamic pumps	K3
CO5	Choose pumps for domestic and industrial applications	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H											H	
CO2	H	H	L										H	
CO3	H	H	L			M	M	H					H	M
CO4	H	H				H							H	M
CO5	H	H	H			H	M	H					H	H

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I MAJOR AND MINOR LOSSES

L-9

Flow through pipes, Reynolds number, major losses-Darcy Weisbach equation, minor losses, Moody's chart and its applications, case studies related to minor and major losses.

UNIT II PUMP PERFORMANCE CHARACTERISTICS

L-9

Pump terminologies, losses in pumps, plotting of head-discharge characteristics, power consumption, Pump characteristics of radial, mixed, and axial flow pumps, affinity law of characteristics curves, series and parallel pump characteristics.

UNIT III SELECTION, INSTALLATION, AND COMMISSIONING**L-9**

System curve, static head, dynamic head calculation, straight pipe equivalent length, components of pumps – stuffing box, mechanical seal, pump selection, cavitation in pumps, and installation of pumps.

UNIT IV PUMP TESTING**L-9**

Pump testing – classification of tests, general principles of testing, measurement of characteristics quantities, test rig for rotodynamic pumps, acceptance test, measurement error.

UNIT V APPLICATIONS OF PUMPS**L-9**

Application of pumps – power plant services, subsea applications, processing industries, water supply (domestic and agriculture), jet pumps, submersible pumps, and sewage & sump services, slurry pump, , HVAC pumps, solar based water pumping.

TOTAL: 45 PERIODS**8. Text Books**

1. Karassik, I. Centrifugal Pump Clinic. 2nd Ed., New York, CRC Press, 2017.
2. Guelich, J.F. Centrifugal Pumps, Springer Verlag, New York, 2014.

9. References

1. Srinivasan, K. M., Centrifugal Pumps, 1st Edition, New Age International (P) Ltd Publishers, 2016.
2. IS 9137:1978 (Reaffirmed 2002) Code for Acceptance Test for Centrifugal, Mixed Flow and Axial Pumps – Class C
3. Stepanoff, A.J. Centrifugal and Axial Flow Pumps. 2nd Ed., John Wiley, New York, 1991.
4. Lazarkiewicz, S. and Troskolanski, A, T. Impeller Pumps. Pergamon press, Oxford, 1965.
5. Kovats, A. Design and Performance of Centrifugal and Axial Flow Pumps and Compressors. Pergamon Press, New York, 1964.

COURSE CODE	DESIGN OF ROTODYNAMIC PUMPS	L	T	P	C
10212ME130		3	0	0	3

1. Preamble

To enrich the knowledge about roto dynamic pumps and as well as to design the pump for specific requirements.

2. Pre-requisite

10211ME208-Fluid Mechanics and Machinery

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- To familiarize with velocity triangles for pumps of various classification
- To familiarize with the design of radial flow, mixed flow, and axial flow pumps based on the various requirements.
- To emphasis the effects of cavitation in pumps and the effects of cavitation on performance of the pumps.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Distinguish between rotodynamic and positive displacement pumps and draw velocity triangles for pumps	K3
CO2	Calculate the dimensions of impeller and vane of a radial flow pumps and analyze the characteristic curves.	K3
CO3	Design and analyze the performance characteristics of mixed flow pumps	K4
CO4	Design outlet elements of axial flow pump for high flow rate applications	K3
CO5	Describe the cavitation parameters and methods to reduce cavitation in pumps	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H											H	
CO2	H	H	H			M	M	M					H	M
CO3	H	H	H			M	M	M					H	M
CO4	H	H	H			M	M	M					H	M
CO5	H	H											H	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION ON PUMPS

L-9

Fundamental definitions about pumps, classification of pumps, Specific speed, pump theory, comparison between rotodynamic pumps and positive displacement pumps, construction of inlet and outlet velocity triangles for the blades of pumps, theoretical head of centrifugal pump derivation, and outline of various impeller losses.

UNIT II DESIGN OF RADIAL FLOW PUMP**L-9**

Definition of turbo machine - Components of pump - Design of radial flow pump – calculation of the dimensions of the impeller (detailed steps), shaping of blade/vane course – circular arc method (single and double arc) – point by point method, cross section of the impeller passage – critical speed – performance characteristics of radial flow pump (glimpse)

UNIT III DESIGN OF MIXED FLOW PUMP AND INLET ELEMENTS**L-9**

Mixed flow pump – Helical pump, diagonal pump, design calculation of a mixed flow pump – inlet constriction coefficient - plotting streamlines – inlet and outlet velocity triangles - shaping of blade surfaces – Kaplan Error Triangle method – performance characteristics of mixed flow pump (glimpse) – design of inlet elements.

UNIT IV DESIGN OF AXIAL FLOW PUMP AND OUTLET ELEMENTS**L-9**

Axial flow pump - introduction – inlet and outlet velocity triangles – various design methods – one dimensional flow method - aerofoil theory – NACA Profile - aerodynamic method – stacking of vane sections, design of outlet elements – types of casing – design steps of volute casing.

UNIT V CAVITATION**L-9**

Cavitation in pumps – symptoms of cavitation – operating condition of pump - cavitation parameters – energy diagram at pump suction side - types of impeller cavitation – Net Positive Suction Head – case studies on NPSH (problem) – Method of cavitation test - Trouble shooting in Pumps

TOTAL: 45 PERIODS**8. Text Books**

1. Karassik, I. Centrifugal Pump Clinic. 2nd Ed., New York, CRC Press, 2017.
2. Srinivasan, K. M., Centrifugal Pumps, 1st Edition, New Age International (P) Ltd Publishers, 2016.
3. Guelich, J.F. Centrifugal Pumps, Springer Verlag, New York, 2014.

9. References

1. Neumann, B. The Interaction between Geometry and Performance of a Centrifugal Pump. MEP, London, 2005.
2. Kumaraswamy, S. Data Book for Design of Centrifugal Pumps. Hydroturbomachines Lab., Indian Institute of Technology Madras, 2001.
3. Li, S.C. Cavitation of Hydraulic Machinery, London Imperial College press, 2000.
4. John Tuzson, Centrifugal Pump Design, Wiley Publisher, India, 2000.
5. Stepanoff, A.J. Centrifugal and Axial Flow Pumps. 2nd Ed., John Wiley, New York, 1991.
6. Lazarkiewicz, S. and Troskolanski, A, T. Impeller Pumps. Pergamon press, Oxford, 1965.

COURSE CODE	SOLAR ENERGY ENGINEERING	L	T	P	C
10212ME131		3	0	0	3

1. Preamble

To understand the fundamentals of solar energy and its conversion techniques for both thermal and electrical energy applications.

2. Pre-requisite

10212ME117-Renewable Sources of Energy

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the origin of solar energy and learn the solar radiation principles
- Learn the solar energy conversion principles and technologies
- Understand the environmental merits, applications and prospects of solar energy.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Explain the measurement and estimation of solar radiation	K2
CO2	Illustrate the working principle of solar thermal collector and its performance.	K3
CO3	Illustrate the characteristic of PV cell, solar array and estimation of solar cell load.	K3
CO4	Describe the various forms of solar passive architecture and different kinds of thermal storage devices.	K2
CO5	Explain the different applications of solar energy devices.	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	M					M						M	
CO2	H	M					H						H	L
CO3	H	M					H						H	L
CO4	M	M					M						M	
CO5	M	M					M						M	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION TO SOLAR ENERGY

L-9

Basics of solar energy - Brief history of solar energy utilization - Various approaches of utilizing solar energy – Source of radiation - Blackbody radiation – solar constant. Solar angles - day length, angle of incidence on tilted surface - Sunpath diagrams – shadow determination - extraterrestrial characteristics - measurement and estimation on horizontal and tilted surfaces. Measurement of diffuse, global and direct solar radiation: pyrliometer, pyranometer, sunshine recorder.

UNIT II SOLAR THERMAL COLLECTORS

L-9

Flat plate collector – Thermal analysis - Evacuated tubular collector – Concentrator collectors - classification - design and performance parameters - Pool and Air collectors - Construction –

Function - Suitability – Comparison - Storage Tank. Concentrating Dish Systems - Concentrating Linear Fresnel Reflectors - Hybrid Systems. Tracking systems - compound parabolic concentrators - parabolic trough concentrators - concentrators with point focus - Heliostats – performance of the collectors.

UNIT III SOLAR PV SYSTEMS AND ITS APPLICATIONS

L-9

Solar photovoltaic energy conversion - Principles - Physics and operation of solar cells. Classification of solar PV systems, Solar cell energy conversion efficiency, I-V characteristics, effect of variation of solar insolation and temperature, losses. Solar PV power plants. Building-integrated photovoltaic units, grid-interacting central power stations, stand-alone devices for distributed power supply in remote and rural areas, solar cars, aircraft, space solar power satellites. Socio-economic and environmental merits of photovoltaic systems.

UNIT IV SOLAR THERMAL ENERGY STORAGE

L-9

Basics of thermal energy storage systems. Necessity of storage for solar energy- Chemical energy storage - Thermal energy storage - Thermal Flywheels - Compressed air- Rechargeable batteries. Design aspects of solar thermal energy storage systems. Selection criteria of storage materials for heating and cooling applications, selection of heat transfer fluid for heating and cooling applications. Design of LHTES for solar process heating and power generation applications. Performance and evaluation of solar thermal energy storage system.

UNIT V APPLICATIONS OF SOLAR THERMAL ENERGY

L-9

Heat Delivery Methods - Air and Liquid type Solar Heating Systems - Solar Refrigeration and Air Conditioning. Solar Cooking – Distillation - Desalination – Solar Still - Solar Ponds – Solar Drying – Solar Chimney. Photovoltaic Power Systems - System Integration - Energy Storage - Stand-Alone Systems - Grid-Connected Systems - PV System in Buildings. Solar thermal power plants - Parabolic trough system, distributed collector, hybrid solar-gas power plants, solar pond based electric-power plant, central tower receiver power plant.

TOTAL: 45 PERIODS

8. Text Books

1. Kalogirou Soteris A., Solar Energy Engineering, Fourth Edition, Elsevier Science Publishing Co Inc, 2019.
2. Chetan Singh Solanki, Solar Photovoltaics – Fundamentals, Technologies and Applications, Prentice Hall India, 2015.
3. Duffie and W. A. Beckman, Solar Engineering of Thermal Processes, Third Edition, John Wiley and Sons, 2006.
4. Garg H P., Prakash J., Solar Energy: Fundamentals & Applications, Tata McGraw

9. References

1. Chetan Singh Solanki, Solar Photovoltaics, "Fundamentals, Technologies and Applications", PHI Learning Private Limited, New Delhi, 2009.
2. Sukhatme. S.P., "Solar Energy", Tata McGraw Hill Publishing Company Ltd., New Delhi, 1997.
3. Godfrey Boyle, "Renewable energy", Open University, Oxford University Press in association with the Open University, 2004.

COURSE CODE	INDUSTRIAL ENGINEERING AND MANAGEMENT	L	T	P	C
10212ME132		3	0	0	3

1. Preamble

This course makes an attempt to bring students in direct contact with the working environment of an industry. It empowers the students to amalgamate their knowledge of production, process planning & control, maintenance and system analysis.

2. Pre-requisite

NIL

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Be familiar with fundamentals of various science and technological subjects and thus acquire the capability to applying them.
- Equip knowledge and skills necessary for entry-level placement in MNC's.
- Develop capacity to understand professional and ethical responsibility and to display skills required for continuous and lifelong learning and up gradation.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Explain the different types of production layouts and factors affecting productivity	K2
CO2	Describe the scheduling, process chart and symbols for process planning and control.	K2
CO3	Illustrate the types work study and motion study principle, procedure and measurement.	K3
CO4	Apply manufacturing resource planning procedure and material handling equipment for inventory control	K3
CO5	Explain the classifications of system analysis and maintenance.	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M											M	
CO2	H	M											M	
CO3	H	H	M								M		M	L
CO4	H	H	M								M		M	
CO5	H	M											M	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I PRODUCTION SYSTEM

L-9

Industrial engineering - Concept, History and development, Applications, Roles of Industrial engineer. Production management, Industrial engineering versus production management, Operations Management. Production system – Analysis, Input output model, Productivity, Factors affecting productivity. Plant layout, Process layout, Product layout, Combination layout, fixed position layout, Flow pattern, and Workstation design.

UNIT II PROCESS PLANNING AND CONTROL**L-9**

Process planning – definition, procedure, Process selection, Machine capacity, process sheet, process analysis, process chart – symbols, outline process chart, flow process chart. Group technology – functional and group layout, classification and coding system, formation of component family. Production planning, economic batch quantity, loading, scheduling. Production control – dispatching, routing. Progress control – bar, curve, Gantt chart, route & schedule chart, line of balance.

UNIT III WORK STUDY**L-9**

Work study – definition, need, advantages, objectives of method study and work measurement, method study procedure, flow diagram, string diagram, multiple activity chart, operation analysis, analysis of motion, principles of motion economy, design of work place layout & ergonomics, therbligs, SIMO chart, stop watch procedure, micro & macro motion study. Predetermined motion time system, work sampling – principle, procedure.

UNIT IV INVENTORY MANAGEMENT**L-9**

Inventory – control, classification, management, objectives, functions. Economic order quantity, Inventory models, ABC analysis, Material Requirement Planning (MRPI), Manufacturing Resource Planning(MRP II), Operating cycle, Just in Time manufacturing system, KANBAN technique, lean manufacturing, Supply chain management. Material handling – functions, principles, Engineering and economic factors, Material handling equipment – selection, maintenance, types.

UNIT V SYSTEM ANALYSIS AND MAINTENANCE**L-9**

System concept - system analysis, systems engineering, techniques, applications. Value analysis – aim, technique, procedure, advantages, value engineering, value control, types of values. Re-engineering, Business process re-engineering. Plant maintenance – objectives, importance, maintenance engineer – duties, functions and responsibilities. Types – breakdown, scheduled, preventive, predictive - seminar

TOTAL: 45 PERIODS**8. Text Books**

1. O. P. Khanna, *Industrial Engineering and Management*, Dhanpat Rai and Sons, New Delhi, 2008
2. Hamdy M. Taha, *Operations Research, an Introduction*, McMillan Co., 2008

9. References

1. J. A. Tompkins and J. A. White, *Facilities planning*, John Wiley, 2010.
2. Benjamin W. Neibel, *Motion and time study*, Richard .D .Irwin Inc., 2006.
3. Lee J. Krajewski, Larry P. Ritzman, *Operations Management*, Addison Wesley, 2007.
4. Ravi Shankar, *Industrial Engineering and Management*, Golgotia publications Pvt Ltd, New Delhi, 2009.

COURSE CODE	TOTAL QUALITY MANAGEMENT	L	T	P	C
10212ME133		3	0	0	3

1. Preamble

To provide comprehensive knowledge about the principles, practices, tools and techniques of Total quality management.

2. Pre-requisite

NIL

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- To understand the various principles, practices of TQM to achieve quality.
- To learn the various statistical approaches for Quality control.
- To understand the TQM tools for continuous process improvement.
- To learn the importance of ISO and Quality systems

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Explain the basic principles, framework, and barriers of total quality management.	K2
CO2	Illustrate the applications of TQM tools for performance appraisal and improvement.	K2
CO3	Describe the uses of seven traditional TQM techniques in manufacturing, service and IT sectors	K2
CO4	Describe the TQM tools for quality function deployment and performance measurement.	K2
CO5	Outline the importance of ISO and Quality systems in manufacturing, service and IT sectors	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	M				H		H					H	
CO2	H	H			M	H		H			M		H	L
CO3	H	H			M	H		H			M		H	L
CO4	M	H			M	H		H			M		H	L
CO5	M	M			M	H		H					H	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION

L-9

Introduction - Need for quality - Evolution of quality - Definition of quality - Dimensions of manufacturing and service quality - Basic concepts of TQM - Definition of TQM – TQM Framework - Contributions of Deming, Juran and Crosby – Barriers to TQM.

UNIT II TQM PRINCIPLES

L-9

Leadership – Strategic quality planning, Quality statements - Customer focus – Customer orientation, Customer satisfaction, Customer complaints, Customer retention – Employee

involvement – Motivation, Empowerment, Team and Teamwork, Recognition and Reward, Performance appraisal - Continuous process improvement – PDSA cycle, 5s, Kaizen.

UNIT III TQM TOOLS & TECHNIQUES I

L-9

The seven traditional tools of quality – New management tools – Six-sigma: Concepts, methodology, applications to manufacturing, service sector including IT – Bench marking – Reason to bench mark, Bench marking process.

UNIT IV TQM TOOLS & TECHNIQUES II

L-9

Quality circles – Quality Function Deployment (QFD) – Taguchi quality loss function – TPM – Concepts, improvement needs – Cost of Quality – Performance measures.

UNIT V QUALITY SYSTEMS

L-9

Need for ISO 9000- ISO 9000-2000 Quality System – Elements, Documentation, Quality auditing- QS 9000 – ISO 14000 – Concepts, Requirements and Benefits – Case studies of TQM implementation in manufacturing and service sectors including IT.

TOTAL: 45 PERIODS

8. Text Books

1. Dale H.Besterfield, et al., “Total Quality Management”, Pearson Education Asia, Third Edition, Indian Reprint (2006).

9. References

1. James R. Evans and William M. Lindsay, “The Management and Control of Quality”, 6th Edition, South-Western (Thomson Learning), 2005.
2. Oakland, J.S. “TQM – Text with Cases”, Butterworth – Heinemann Ltd., Oxford, 3rd Edition, 2003.
3. Suganthi, L and Anand Samuel, “Total Quality Management”, Prentice Hall (India) Pvt. Ltd., 2006.
4. Janakiraman, B and Gopal, R.K, “Total Quality Management – Text and Cases”, Prentice Hall (India) Pvt. Ltd., 2006.

COURSE CODE	SUPPLY CHAIN MANAGEMENT	L	T	P	C
10212ME134		3	0	0	3

1. Preamble

This course provides an update to the knowledge of the students about existing supply-chain practices within the private and public sector of society. Students gain knowledge on applying supply-chain principles to achieve competitive advantage.

2. Pre-requisite

NIL

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the existing SCM practices, logistical principles and integrated logistical Approaches in the private and public sectors.
- Understand the strategic role of a supply-chain , key strategic drivers of supply-chain Performance and analytical methodologies for supply-chain analysis.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Explain the need and role of drivers in supply chain management	K2
CO2	Explain the modes, infrastructure, routing and scheduling of transportation in supply chain	K2
CO3	Illustrate the framework for network design in supply chain	K3
CO4	Describe the role of sourcing and procurement process in supply chain	K2
CO5	Describe the use of IT framework in supply chain management	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M											H	
CO2	H	M											H	
CO3	H	H											H	
CO4	H	M											H	M
CO5	H	H			M								H	M

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION

L-9

Defining Supply Chain management .Evolution. Supply Chain – Fundamentals and Importance. Supply chain strategy, Enablers/ Drivers of Supply Chain Performance.

UNIT II TRANSPORTATION IN A SUPPLY CHAIN

L-9

Role of Transportation ,Modes of Transportation, Transportation Infrastructure, Design Options, The Role of IT in Transportation – Routing and scheduling in transportation - 3PL- 4PL- Global Logistics - Reverse Logistics.

UNIT III NETWORK DESIGN**L-9**

Distribution Network Design – Role, Factors Influencing, Options, Value Additions. Models for Facility Location and Capacity allocation - Role of network Design in Supply Chain – Framework for network Decisions.

UNIT IV SOURCING AND PROCUREMENT**L-9**

Sourcing-Role-Supplier selection-Contracts-Design collaboration-Procurement Process-Value of information, Bullwhip effect, Coordination in supply chain.

UNIT V CURRENT TRENDS**L-9**

E-Business – Framework and Role of Supply Chain in e- business and b2b practices. Supply Chain IT Framework-Supply Chains, Sustainability in supply chain, Role and Key metrics.

TOTAL: 45 PERIODS**8. Text Books**

1. Sunil Chopra and Peter Meindl, Supply Chain Management-Strategy, Planning and Operation, fifth edition, Prentice Hall, 2013.
2. Bowersox Donald J, Logistical Management – The Integrated Supply Chain Process” Tata McGraw Hill, 2000

9. References

1. Donald J. Bowersox, David J. Closs and M. Bixby Cooper, “Supply Chain Logistics Management”, Tata McGraw Hill, 2008
2. Altekhar Rahul V, Supply Chain Management-Concept and Cases, Prentice Hall India, 2005.
3. Joel D. Wisner, G. Keong Leong, Keah-Choon Tan, “Principles of Supply Chain Management- A Balanced Approach”, South-Western, Cengage Learning 2005
4. Naraya Rangarj, G. Raghuram, Mandyam M. Srinivasan, “Supply Chain Management for Competitive Advantage – Concepts and Cases”, Tata McGraw Hill, 2009
5. R.P. Mohanty and S.G. Deshmukh, “Supply Chain Management”, Biztantra, 2005

COURSE CODE	MAINTENANCE ENGINEERING	L	T	P	C
10212ME135		3	0	0	3

1. Preamble

This course develops the skills of the students in the areas of maintenance engineering. Students gain knowledge on different categories like preventive maintenance, condition monitoring. The repair methods of machines and material handling equipment's are explained with illustrations.

2. Pre-requisite

10211ME204 -Manufacturing Technology

10211ME205 - Machining and Machine Tools Technology

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the principles, functions and practices of maintenance planning and policies
- Explain the different maintenance categories like Preventive maintenance, condition monitoring and repair of machine elements.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describe the principles, functions and practices of maintenance planning	K2
CO2	Explain the different types of maintenance, repair cycles and lubrications	K2
CO3	illustrate the methods and instruments used for condition monitoring	K3
CO4	Demonstrate the repair methods for basic machine elements	K3
CO5	Explain the repair methods for material handling equipment	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M											M	
CO2	H	M											M	
CO3	H	H											H	
CO4	H	H	M										M	M
CO5	H	H											M	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I PRINCIPLES AND PRACTICES OF MAINTENANCE PLANNING L-9

Basic Principles of maintenance planning – Objectives and principles of planned maintenance activity – Importance and benefits of sound Maintenance systems – Reliability and machine availability – MTBF, MTTR and MWT – Factors of availability – Maintenance organization – Maintenance economics. Lean management system.

UNIT II MAINTENANCE POLICIES – PREVENTIVE MAINTENANCE L-9

Twelve types of maintenance policies - Maintenance categories – Comparative merits of each category – Preventive maintenance, maintenance schedules, repair cycle - Principles and methods of lubrication – TPM.

UNIT III CONDITION MONITORING L-9

Condition Monitoring – Cost comparison with and without CM – On-load testing and off-load testing – Methods and instruments for CM – Temperature sensitive tapes – Pistol thermometers – wear-debris analysis.

UNIT IV REPAIR METHODS FOR BASIC MACHINE ELEMENTS L-9

Repair methods for beds, slideways, spindles, gears, lead screws and bearings – Failure analysis – Failures and their development – Logical fault location methods – Sequential fault location.

UNIT V REPAIR METHODS FOR MATERIAL HANDLING EQUIPMENT L-9

Repair methods for Material handling equipment - Equipment records –Job order systems - Use of computers in maintenance.

TOTAL: 45 PERIODS

8. Text Books

1. Srivastava S.K., “Industrial Maintenance Management”, - S. Chand and Co., 2002
2. Bhattacharya S.N., “Installation, Servicing and Maintenance”, S. Chand and Co., 1995.

9. References

1. White E.N., “Maintenance Planning”, I Documentation, Gower Press, 1979.
2. Garg M.R., “Industrial Maintenance”, S. Chand & Co., 1987.
3. Higgins L.R., “Maintenance Engineering Hand book”, McGraw Hill, 5th Edition, 2008.
4. Armstrong, “Condition Monitoring”, BSIRSA, 1988.
5. Davies, “Handbook of Condition Monitoring”, Chapman & Hall, 1996.
6. “Advances in Plant Engineering and Management”, Seminar Proceedings - IPE, 1996

COURSE CODE	OPERATIONS RESEARCH	L	T	P	C
10212ME136		3	0	0	3

1. Preamble

To impart knowledge and techniques for optimization in engineering and business problems.

2. Pre-requisite

10210MA205 -Probability and Statistics

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- The students can be able to solve the Engineering and Business problems by using optimization techniques.
- Develop the skills of the students in the areas of Linear Programming, Transportation, Assignment, Network Models, Inventory control and Queuing theory.
- Serve as a prerequisite for the Project work and specialized studies in the research.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Develop linear programming model and solve problems using simplex algorithm.	K3
CO2	Apply modified distribution methods to solve transportation problems.	K3
CO3	Apply CPM and PRERT network model to identify shortest possible route in the given project network model	K3
CO4	Solve deterministic and probabilistic problems for inventory control	K3
CO5	Apply the techniques of queuing theory for real-world applications.	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	H										H	
CO2	H	H	L	L	L							L	H	H
CO3	H	H	L										H	
CO4	H	H	L										H	
CO5	H	H	H	L	L							L	H	H

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I LINEAR PROGRAMMING

L-9

Formulation of linear programming problems – Graphical method of solution– solving LPP using simplex algorithm – Degeneracy- Duality theory- Big-M method and artificial variables.

UNIT II TRANSPORTATION AND ASSIGNMENT PROBLEM

L-9

Mathematical model, balanced and unbalanced Transportation and assignment problem, MODI method – northwest corner method- least cost method – Vogel's approximation methods – travelling salesman problem – assignment problem – types- Hungarian method.

UNIT III NETWORK MODELS**L-9**

Shortest route problem – Maximal flow problem – Minimal spanning tree problem – Project networks- CPM, PERT.

UNIT IV INVENTORY CONTROL**L-9**

Types of inventory- Inventory cost – EOQ – Deterministic inventory problems – EOQ with price breaks– EOQ with storage limitations – probabilistic inventory problems, single period without setup cost, with setup cost.

UNIT V QUEUEING THEORY**L-9**

Queueing system – Characteristics – symbols – Single server queueing models – Multiserver queueing models.

TOTAL: 45 PERIODS**8. Text Books**

1. Handy, A. Taha, "Operations Research", 9th Edition, Prentice Hall of India, New Delhi, 2013
2. R.Panneerselvam, "Operations Research", PHI, Fourth Print, 2008.
3. N. D Vohra, Quantitative Techniques in Management, Tata McGraw Hill, 2010.
4. J.K Sharma " Operations research" theory and applications, Mac Millan, 2009

9. References

1. Hillier, F.S. and Liebermann, G.J., "Introduction to Operations Research", 8th Edition, McGraw Hill, 2010.
2. Philip and Ravindran, "Operations Research", John Wiley, 2010.
3. Tulsian and Pasdey V., "Quantitative Techniques", Pearson – Asia 2010.
4. Gupta, P.K. and Hira, D.S, Operations Research, 3rd Edition, S. Chand and Company Ltd., New Delhi, 2008.

COURSE CODE	MACHINE LEARNING FOR MECHANICAL ENGINEERS	L	T	P	C
10212ME137		3	0	0	3

1. Preamble

This course introduces the learners to data processing, data exploration, visualization and advanced machine learning. It endows the learners with the necessary skills to analyse data and make data driven decisions leveraging machine learning and statistical analysis.

2. Pre-requisite

NIL

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- To identify potential applications of machine learning in practice.
- To represent data as features to serve as input to machine learning models.
- To assess the model quality in terms of relevant error metrics for each task.
- To understand the core differences in analyses enabled by regression and classification.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describe the classifications and applications of machine learning	K2
CO2	Develop data strategy and process for data generation, collection and consumption.	K3
CO3	Apply statistical procedure for data analysis and interpretation	K3
CO4	Explain the conceptual framework of the most commonly used prediction models.	K2
CO5	Explain and apply a set of supervised machine learning concepts and methods	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H												M	
CO2	H	H			M								M	M
CO3	H	H			M								M	M
CO4	H												M	
CO5	H	M											M	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I MACHINE LEARNING FUNDAMENTALS

L-9

Introduction: Predictive Data Analytics, Artificial Intelligence, Machine Learning, Data Science –Extracting Meaningful Patterns, Building Representative Models, Combination of Statistics Machine Learning and Computing – Examples of Machine Learning Applications – Learning Associations, Classification, Regression, Unsupervised Learning, Reinforcement Learning.

UNIT II PREDICTIVE DATA ANALYTICS PROCESS**L-9**

Prior Knowledge – Objective, Subject Area, Data, Causation versus Correlation. Data Preparation – Data Exploration, Data Quality, Missing Values, Data Types and Conversion, Transformation, Outliers, Feature Selection, Data Sampling. Data Modelling – Training and Testing Datasets, Learning Algorithms, Evaluation of the Model, Ensemble Modelling.

UNIT III DATA EXPLORATION AND APPLIED STATISTICS**L-9**

Objectives of Data Exploration – Types of Data – Numeric, Categorical – Univariate Exploration and Visualization – Measures of Central Tendency, Spread, Frequency Distribution Tables, Bar Charts, Histogram, Box Plots, Violin Plots – Multivariate Exploration and Visualization – Covariance and Correlation, Chi-square Test, Z-test, t-test, ANOVA, Scatterplot, Parallel Plots – Roadmap for Data Exploration.

UNIT IV SUPERVISED LEARNING ALGORITHMS: FUNDAMENTALS L-9

Linear Regression – Concepts, Assumptions, Significance of stochastic disturbance term, Multi Collinearity, Heteroscedasticity of disturbance, Loss function, Categorical Independent variables in Regression, Root Mean Square Error, Mean Absolute Error, Pros and Cons – Regularization models – Lasso-Ridge regression model – Logistic Regression – Threshold, Confusion matrix, Accuracy, Precision, Recall.

UNIT V ADVANCED SUPERVISED LEARNING ALGORITHMS**L-9**

Naïve Bayesian – k-Nearest Neighbours – Support Vector Machines – Decision Trees – Artificial Neural Networks.

TOTAL: 45 PERIODS**8. Text Books**

1. Kotu, Vijay, and Bala Deshpande. Data science: concepts and practice. Morgan Kaufmann, 2018.
2. Kelleher, John D., Brian Mac Namee, and Aoife D'arcy. Fundamentals of machine learning for predictive data analytics: algorithms, worked examples, and case studies. MIT press, 2020.

9. References

1. Theobald, Oliver. Machine learning for absolute beginners: a plain English introduction. Scatterplot press, 2017.
2. Spiegelhalter, David. The art of statistics: learning from data. Penguin UK, 2019.

COURSE CODE	THERMAL MANAGEMENT FOR AUTOMOTIVE APPLICATIONS	L	T	P	C
10212ME138		3	0	0	3

1. Preamble

This course provides an update, to the knowledge base of the Mechanical Engineering students, in essential Thermal Management concepts adopted in Internal Combustion Engines. Students may gain knowledge on need for thermal management in IC engines, Cold start thermal management, Battery thermal management, and Engine side thermal management and about the applications of Phase Change Materials in thermal management of IC engines.

2. Pre-requisite

10211ME104 -Engineering Thermodynamics

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Analyze the existing concepts of thermal management systems adopted in heavy vehicles and light duty vehicles.
- Identify the possibilities and methods of improving thermal management concepts on engine side, during cold start conditions, heat energy liberated from battery etc.
- Recommend appropriate materials like coolants, nano-fluids, phase change materials etc., for a specific thermal management application.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Apply thermal management techniques for various requirements of heavy duty vehicles and light duty vehicles.	K3
CO2	Calculate the excess fuel consumption during cold start conditions.	K3
CO3	Perform the heat balance calculations based on the intake air temperature, exhaust gas temperature, coolant temperature etc.	K3
CO4	Estimate the heat energy liberated from the batteries, used in automobiles, and suggest suitable methods to carry out the excess heat.	K3
CO5	Choose appropriate materials like coolants, nano-fluids, phase change materials for a specific thermal management application.	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	M										H	L
CO2	H	H	M				L						H	L
CO3	H	H	H										H	L
CO4	H	H	H				L						H	L
CO5	H	H	M				H	M					H	L

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION TO THERMAL MANAGEMENT IN AUTOMOTIVE APPLICATIONS L-9

Need and requirements for Thermal Management - Thermal Management Concepts for Higher-Efficiency Heavy Vehicles – Thermal Management on Small Gasoline Engines - Under hood Thermal Management by Controlling Air Flow

UNIT II COLD START THERMAL MANAGEMENT L-9

Cold Start Thermal Management with Electrically Heated Catalyst: A Way to Lower Fuel Consumption - Heat Management By Means Of Thermal Barriers of Ceramic Fibers in Automotive Components and Systems.

UNIT III ENGINE THERMAL MANAGEMENT L-9

Intake Air Temperature Management, Exhaust Gas Thermal Management Engine Thermal Management with Electric Cooling Pump - Coolant Flow Control Strategies for Automotive Thermal Management Systems – Smart Thermostat and Coolant Pump Control for Engine Thermal Management Systems.

UNIT IV BATTERY THERMAL MANAGEMENT L-9

Battery thermal management system: Definition - Parts: Power Module- Battery-communication channel- Battery Heat Transfer Analysis -Battery Temperature Distribution - Battery Temperature Uniformity. Battery cooling: fins, air, or a liquid coolant.

UNIT V ADVANCED MATERIALS ON THERMAL APPLICATIONS L-9

Phase change material- characteristics- PCM in vehicle applications. -Nano materials- characteristics- nanofluids on automotive thermal system. Case studies on PCM and Nanomaterial in Automotive thermal systems. Nanofluids for Vehicle Thermal Management.

TOTAL: 45 PERIODS

8. Text Books

1. T. Yomi Obidi, Thermal Management in Automotive Applications, SAE International ISBN of 978-0-7680-8174-9.

9. References

1. Joseph Wagner; Kirk VanGelder, Automotive Heating, Ventilation, and Air Conditioning, CDX Automotive, 2019.
2. Paul Lung- "Automotive Air Conditioning"- C.B.S. Publisher & Distributor- Delhi
3. Ibrahim Dincer- Halil S. Hamut and Nader Javani- "Thermal Management of Electric Vehicle Battery Systems"- John Wiley& Sons Ltd.- 2016.

COURSE CODE	INTRODUCTION TO ARTIFICIAL INTELLIGENCE	L	T	P	C
10212ME139		3	0	0	3

1. Preamble

This course addresses basic fundamental experience with algorithms in the artificial intelligence.

2. Pre-requisite

NIL

3. Link to the other courses

10212ME128 -Artificial Intelligence System in Manufacturing Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- To make the scholar familiar with the application of normative ethics, metaethics and practical ethics to the field of AI and to AI technologies.
- To know the software qualities, black box algorithms, epistemic opacity, and the paradox of capacity.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describe the tree and graph structures of artificial intelligence	K2
CO2	Illustrate the types and applications of search algorithms in artificial intelligence	K3
CO3	Apply the probabilistic reasoning to identify unpredictable solutions in artificial intelligence	K3
CO4	Apply markov decision process to predict the outcomes of the given information.	K3
CO5	Describe the types and applications of reinforcement learning in artificial intelligence	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M											L	
CO2	H	H	M		M								M	
CO3	H	H	M		M								M	
CO4	H	H	M		M								L	
CO5	H	M											L	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION

L-3

Concept of AI, history, current status, scope, agents, environments, Problem Formulations, Review of tree and graph structures, State space representation, Search graph and Search

tree.

UNIT II SEARCH ALGORITHMS

L-10

Random search, Search with closed and open list, Depth first and Breadth first search, Heuristic search, best first search, Algorithm, Game Search.

UNIT III PROBABILISTIC REASONING

L-11

Probability, conditional probability, Bayes Rule, Bayesian Networks- representation, construction and inference, temporal model, hidden Markov model.

UNIT IV MARKOV DECISION PROCESS

L-11

MDP formulation, utility theory, utility functions, value iteration, policy iteration and partially observable MDPs.

UNIT V REINFORCEMENT LEARNING

L-10

Passive reinforcement learning, direct utility estimation, adaptive dynamic programming, temporal difference learning, active reinforcement learning- Q learning.

TOTAL: 45 PERIODS

8. Text Books

1. Stuart Russell and Peter Norvig, "Artificial Intelligence: A Modern Approach", 3rd Edition, Prentice Hall
2. Elaine Rich and Kevin Knight, "Artificial Intelligence", Tata McGraw Hill

9. References

1. Trivedi, M.C., "A Classical Approach to Artificial Intelligence", Khanna Publishing House, Delhi.
2. Saroj Kaushik, "Artificial Intelligence", Cengage Learning India, 2011.

COURSE CODE	FUNDAMENTALS OF MACHINE LEARNING	L	T	P	C
10212ME140		3	0	0	3

1. Preamble

This course introduces the learners to data processing, data exploration, visualization and advanced machine learning. It endows the learners with the necessary skills to analyse data and make data driven decisions leveraging machine learning and statistical analysis.

2. Pre-requisite

NIL

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- To identify potential applications of machine learning in practice.
- To represent data as features to serve as input to machine learning models.
- To assess the model quality in terms of relevant error metrics for each task.
- To understand the core differences in analyses enabled by regression and classification.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Understand the basic theory underlying the field of machine learning	K2
CO2	Develop data strategy and process for how data is generated, collected and consumed	K3
CO3	Understand and appreciate statistical data analysis procedure as well as develop skills in analysis and interpretation of data	K3
CO4	Understand the conceptual framework of the most commonly used prediction models.	K2
CO5	Explain and apply supervised machine learning concepts and methods	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1				M	M								M	
CO2		L		H	M						L		M	
CO3		L		H	H						L		M	
CO4				M	H								M	
CO5				M	H								M	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I MACHINE LEARNING FUNDAMENTALS

L-9

Introduction: Predictive Data Analytics, Artificial Intelligence, Machine Learning, Data Science –Extracting Meaningful Patterns, Building Representative Models, Combination of Statistics Machine Learning and Computing – Examples of Machine Learning Applications – Learning Associations, Classification, Regression, Unsupervised Learning, Reinforcement Learning.

UNIT II PREDICTIVE DATA ANALYTICS PROCESS

L-9

Prior Knowledge – Objective, Subject Area, Data, Causation Versus Correlation. Data Preparation – Data Exploration, Data Quality, Missing Values, Data Types and Conversion, Transformation, Outliers, Feature Selection, Data Sampling. Data Modelling – Training and Testing Datasets, Learning Algorithms, Evaluation of the Model, Ensemble Modelling.

UNIT III DATA EXPLORATION AND APPLIED STATISTICS

L-9

Objectives of Data Exploration – Types of Data – Numeric, Categorical – Univariate Exploration and Visualization – Measures of Central Tendency, Spread, Frequency Distribution Tables, Bar Charts, Histogram, Box Plots, Violin Plots – Multivariate Exploration and Visualization – Covariance and Correlation, Chi-square Test, Z-test, t-test, ANOVA, Scatterplot, Parallel Plots – Roadmap for Data Exploration.

UNIT IV SUPERVISED LEARNING ALGORITHMS: FUNDAMENTALS

L-9

Linear Regression – Concepts, Assumptions, Significance of stochastic disturbance term, Multi Collinearity, Heteroscedasticity of disturbance, Loss function, Categorical Independent variables in Regression, Root Mean Square Error, Mean Absolute Error, Pros and Cons – Regularization models – Lasso-Ridge regression model – Logistic Regression – Threshold, Confusion matrix, Accuracy, Precision, Recall.

UNIT V ADVANCED SUPERVISED LEARNING ALGORITHMS

L-9

Naïve Bayesian – k-Nearest Neighbours – Support Vector Machines – Decision Trees – Artificial Neural Networks.

TOTAL: 45 PERIODS

8. Text Books

1. Kotu, Vijay, and Bala Deshpande. Data science: concepts and practice. Morgan Kaufmann, 2018.
2. Kelleher, John D., Brian Mac Namee, and Aoife D'arcy. Fundamentals of machine learning for predictive data analytics: algorithms, worked examples, and case studies. MIT press, 2020.

9. References

1. J Theobald, Oliver. Machine learning for absolute beginners: a plain English introduction. Scatterplot press, 2017.
2. Spiegelhalter, David. The art of statistics: learning from data. Penguin UK, 2019.

COURSE CODE	ETHICAL AND SOCIAL IMPLICATIONS OF ARTIFICIAL INTELLIGENCE	L	T	P	C
10212ME141		3	0	0	3

1. Preamble

This course provides a study problem from multiple perspectives. The students are able to learn how to frame the design challenge properly in AI and how to ideate, prototype and Iterate solutions with AI.

2. Pre-requisite

NIL

3. Link to the other courses

Project Work

10212ME128 -Artificial Intelligence System in Manufacturing

4. Course Educational Objectives

Students, after undergoing this course would

- Study a problem from multiple perspectives
- Learn how to frame the design challenge properly in AI.
- Learn how to ideate, prototype and Iterate solutions with AI.
- Learn from the overall design process how to create value as entrepreneurs.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describe the concept of artificial intelligence with big data and human identity.	K2
CO2	Explain the concept of ethics of information and Ethics of artificial intelligence	K2
CO3	Describe the software qualities and normative ethics related to web-based applications	K2
CO4	Describe the strong artificial intelligence as potential epistemic and moral agents	K2
CO5	Explain the artificial intelligence algorithms and existential threat	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M						M					L	
CO2	H	M						M					M	
CO3	H	H						M					M	
CO4	H	M						M					M	
CO5	H	M						M					M	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION

L-8

AI, information transmission, information processing, and privacy, Big data and privacy, Big data and human identity, Big data, recurrent neural nets, black boxes, and social construction.

UNIT II ETHICS OF INFORMATION AND ETHICS OF AI

L-12

Ethical issues for different strengths/grades of AI and AI algorithms, Medium to strong AI: the moral relevance and effects of its ontological differences, Software qualities: document ability, readability, interpretability, and transparency, Care ethics, Virtue Ethics, Problems with implementation, Problems with uptake and enforcement.

UNIT III SOFTWARE QUALITIES AND NORMATIVE ETHICS

L-12

Interpretability, transparency and normative ethics, Interpretability, transparency and policy making, Extensibility, usability, and communicability, Ethics of AI on the Web and in Web based applications, AI technology and social hierarchy.

UNIT IV STRONG AIs AS POTENTIAL EPISTEMIC AND MORAL AGENTS

L-8

Models, representations, and introspections, Interventions and counterfactuals, Emulating plasticity: synaptic plasticity versus intrinsic plasticity, Imagination.

UNIT V AI ALGORITHMS AND EXISTENTIAL THREAT

L-5

AI Surveillance, Autonomous Weapons and Drones, AI Bias

TOTAL: 45 PERIODS

8. Text Books

1. Bauer, W. A. (2020). Virtuous vs. utilitarian artificial moral agents. AI and Society. <https://doi.org/10.1007/s00146-018-0871-3>
2. Bryson, J. J. (2018). Patency is not a virtue: the design of intelligent systems and systems of ethics. Ethics and Information Technology. <https://doi.org/10.1007/s10676-018-9448-6>
3. Floridi, L. (2016). Faultless responsibility: On the nature and allocation of moral responsibility for distributed moral actions. Philosophical Transactions. Series A, Mathematical, Physical, and Engineering Sciences, 374(2083), 1–13.
4. Etzioni, A., & Etzioni, O. (2016). AI assisted ethics. Ethics and Information Technology. <https://doi.org/10.1007/s10676-016-9400-6>

9. References

1. Feng, Z. (2018). Does AI Share same ethic with human being?: From the perspective of virtue ethics. IFIP Advances in Information and Communication Technology. https://doi.org/10.1007/978-3-030-01313-4_49
2. Hagendorff, T. (2020). The Ethics of AI Ethics: An Evaluation of Guidelines. Minds and Machines. <https://doi.org/10.1007/s11023-020-09517-8>
3. Hooker, J., & Hooker, J. (2018). Ethics of Artificial Intelligence. In Taking Ethics Seriously. <https://doi.org/10.4324/9781315097961-14>
4. Mittelstadt, B. (2019). AI Ethics – Too Principled to Fail? SSRN Electronic Journal. <https://doi.org/10.2139/ssrn.3391293>
5. McDermott, D. (2008). Why ethics is a high hurdle for AI. North American Conference on Computers and Philosophy (NA-CAP)

COURSE CODE	ARTIFICIAL INTELLIGENCE AND DESIGN THINKING	L	T	P	C
10212ME142		3	0	0	3

1. Preamble

This course addresses the artificial intelligence and design thinking, design challenges and testing and documentation of AI.

2. Pre-requisite

10212ME139 -Introduction To Artificial Intelligence

3. Link to the other courses

10212ME128 -Artificial Intelligence System in Manufacturing Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- To make the scholar familiar with the design thinking challenges in artificial intelligence.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Apply design thinking to explore and define the opportunities of AI technologies	K3
CO2	Explain design thinking procedure in automation opportunities	K2
CO3	Discuss the design challenges of artificial intelligence with eco system	K2
CO4	Explain the uses of AI in prototype testing and documentation	K2
CO5	Discuss the different types of artificial intelligence models	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M											H	
CO2	H	M											H	
CO3	H	M											H	
CO4	H	M											H	
CO5	H	M											H	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION

L-8

Introduction to Design Thinking: LRI Assessment, Introduction to Design Thinking, Understanding the Mindsets-Empathy, Optimism, Embrace Ambiguity, make it, Learn from Failure, Iterate, Create Confidence, Creativity Convergent & Divergent Thinking.

UNIT II DESIGN THINKING OF AI**L-12**

Design Thinking Methodology: The 5 Stages of the Design Thinking Process-Empathise, define (the problem), Ideate, Prototype, and Test, Identifying User Needs and Automation/Augmentation Opportunities, Design: Wizard-of-Oz Need finding Systems.

UNIT III DESIGN CHALLENGES**L-12**

Ideation tools & exercises. Sample Design Challenge, Introduction to the Design Challenge Themes, Tools for Innovation, AI + Design Thinking is based on an AI ecosystem which in addition to the technology includes users.

UNIT IV TESTING AND DOCUMENTATION OF AI**L-8**

The Design Challenge: Define the Design Challenge, Prototyping & Iteration- Feasibility Study, Testing-Documentation and the Pitch.

UNIT V AI MODELS**L-5**

Aligning Mental and Machine Learning Models, Training Machine Learning Models, Evaluating Data-Driven Products with User-Centered Metrics, Deploying Machine Learning Models and Staging Automation.

TOTAL: 45 PERIODS**8. Text Books**

1. Design Thinking for Strategic Innovation: What They Can't Teach You at Business or Design School - Idris Mootee.
2. An AVA Book, "Design Thinking", AVA Publishing, 2010

9. References

1. Stuart Russell and Peter Norvig, "Artificial Intelligence: A Modern Approach", 3rd Edition, Prentice Hall.

COURSE CODE	INDUSTRIAL APPLICATIONS OF ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING	L	T	P	C
10212ME204		1	0	2	3

1. Preamble

This course imparts the knowledge to understand the fundamental concepts of artificial intelligence, machine learning and computer vision. It equips the learners with essential computer skills needed to perform in silico experiments in AI.

2. Pre-requisite

10212ME139 -Introduction To Artificial Intelligence

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- To learn to program and analyse data with Python.
- To apply supervised and unsupervised learning concepts and methods.
- To master the fundamentals of imaging processing.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Apply python programming to develop models for AI & ML	K3
CO2	Interpret any mechanical system as an input-output system.	K3
CO3	Illustrate the use of machine learning algorithms in regression and classification.	K3
CO4	Develop AI based decision models for mechanical engineering applications	K3
CO5	Apply the AI models and tools for computer vision applications.	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	M	L	M								H	M
CO2	H	H	L	L	M								H	
CO3	H	H											H	
CO4	H	H	M		M								H	M
CO5	H	H	L	L	M								H	L

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I PYTHON PROGRAMMING FOR AI & ML

L-3 P- 6

Python Functions, Types and Sequences, Strings, Reading and Writing CSV files, Dates and Times, Objects, Numerical Python Library (NumPy), Pandas, Data Structure, Querying, Data Frames.

Experiments: NumPy examples, Data wrangling with Pandas, Exploratory data analysis.

UNIT II DATA-DRIVEN MECHANICAL PROCESSES

L-3 P- 6

Viewing Mechanical Processes as Input-Output Systems, Sampling, Data Collection, Data Manipulation, Missing Data Handling

Experiments: Case study on data driven thermal/ manufacturing/ design engineering application.

UNIT III PREDICTIVE ANALYTICS

L-3 P- 6

Introduction to Supervised Machine Learning, Regression, Model Parameters, Model Evaluation, Introduction to Classification, Evaluating Classification Models.

Experiments: Training a Regression Model, Training a Multiclass Model.

UNIT IV DECISION MAKING WITH AI

L-3 P- 6

Optimizing Operating Conditions of Industrial Machinery, Predictive Maintenance, Defective Part Classification

Experiments: Case study on gear box fault diagnosis.

UNIT V MACHINE VISION

L-3 P- 6

Computer Vision, Open CV and Tensor Flow for Computer Vision Tasks, Reading, Writing and Displaying Images

Experiments Object Detection, Image Segmentation.

TOTAL: 45 PERIODS

8. Text Books

1. Computer Vision: Algorithms and Applications, by Richard Szeliski, Springer, 2010.
2. Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow: Concepts, tools, and techniques to build intelligent systems, by Géron, Aurélien, O'Reilly Media, 2019.

9. References

1. Burkov, Andriy. The hundred-page machine learning book. Vol. 1. Canada: Andriy Burkov, 2019.
2. Raschka, S. (2015). Python machine learning. Packt publishing ltd.

COURSE CODE	FUNDAMENTALS OF COMPUTER VISION	L	T	P	C
10212ME143		3	0	0	3

1. Preamble

This course introduces learners to computer vision, key application areas of computer vision and digital imaging process. It endows the learners with the necessary skills to apply mathematical techniques to complete computer vision tasks.

2. Pre-requisite

NIL

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- To understand what computer vision is, its goals and key application areas
- To be able to work with images and build simple models for identification
- To apply transfer learning to solve complex problems in working with images
- To be able to use detectors and recognizes in transfer learning to solve a problem of image recognition.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describe the need, impact, application of computer vision in the field of augmented reality	K2
CO2	Classify light sources and low, mid, and high level vision systems.	K3
CO3	Use linear algebra, calculus, probability theory for computer vision.	K3
CO4	Explain the conceptual framework and types of machine learning algorithms for computer vision.	K2
CO5	Explain and apply neural networks in computer vision applications	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	L											M	
CO2	H	H											H	
CO3	H	H	M										H	L
CO4	H	L											M	L
CO5	H	H	M										H	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I COMPUTER VISION FUNDAMENTALS

L-9

Computer Vision, Need for Computer Vision, Related Fields, Computer Vision Applications, CV Impact in the Field of Augmented Reality.

UNIT II IMAGE & VISION

L-9

Light Sources, Pinhole Camera Model, Digital Camera, Colour Theory - Three-Level Paradigm, Low-Level Vision, Mid-Level Vision, High-Level Vision.

UNIT III MATHEMATICS FOR COMPUTER VISION**L-9**

Mathematic Skills, Mathematical Preliminaries, Linear Algebra, Calculus, Probability Theory, Algorithms, Using Algorithms, Aligning RGB channels.

UNIT IV MACHINE LEARNING IMAGE CLASSIFICATION**L-9**

Naïve Bayesian – k-Nearest Neighbours – Support Vector Machines – Decision Trees – Artificial Neural Networks.

UNIT V NEURAL NETWORKS AND DEEP LEARNING FOR IMAGE CLASSIFICATION**L-9**

Neural Networks, Fully Connected Neural Network Architecture, Convolutional Networks, CNN Architectures, ReLU, ResNet, LenNet.

TOTAL: 45 PERIODS**8. Text Books**

1. Computer Vision: Algorithms and Applications, by Richard Szeliski, Springer, 2010.
2. Computer Vision: A Modern Approach (2nd edition), by D.A. Forsyth and J. Ponce, Prentice Hall, 2011.

9. References

1. Davies E. R., "Machine Vision: Theory, Algorithms, Practicalities", Morgan Kaufmann, 2004.
2. Jain R., Kasturi R. and Shunck B. G., "Machine Vision", McGraw Hill.

COURSE CODE	INTRODUCTION TO ROBOTICS	L	T	P	C
10212ME144		3	0	0	3

1. Preamble

This course is designed to provide knowledge about the concepts of various tools and approaches available for product design and process development.

2. Pre-requisite

NIL

3. Link to the other courses

Project Work

Total Quality Management

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the concepts of the robot to the operation of the robot which includes components, parts, operations, and programming
- It gives a complete idea about the unmanned vehicle and a strong basis for the development of the new robot.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describe the types and basic robot motions of robot	K2
CO2	Illustrate the features, specifications, operations, and applications of unmanned vehicles.	K3
CO3	Describe the functions of robot drivers, actuators, sensors, and grippers.	K2
CO4	Explain the basic operation , programming and applications of robot in AI & ML	K2
CO5	Explain the uses of robot for Humanoid and industrial applications	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M											H	
CO2	H	H											H	
CO3	H	M											H	
CO4	H	M											H	
CO5	H	H											H	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION

L-9

History of the robot - Robot Laws - Types of robots - Robot configuration - Advantages of the robot - Disadvantages of the robot - Basic robot motions - continuous and point to point.

UNIT II UNMANNED VEHICLES**L-9**

Basic of unmanned vehicles - Opportunities and challenges – UAV - Features, specifications, operations, applications - USV - Features, specifications, operations, applications - UUV - Features, specifications, operations, applications – ROV – AUV - special robot (space robot).

UNIT III BASIC COMPONENTS**L-9**

Robot anatomy - Robot drives and actuators - Basic of Sensors - Range, proximity, touch, force and torque sensors - End effector - Types of Grippers.

UNIT IV ROBOT OPERATIONS**L-9**

Robot developing concept - Control and communication - Programming languages - Capabilities and limitation - Kinematics and inverse kinematics - Basic of AI & ML - Knowledge representation - Application of AI and ML.

UNIT V CASE STUDY OF ROBOT**L-9**

Humanoid robot - Industrial robot – UAV - USV UGV – UUV

TOTAL: 45 PERIODS**8. Text Books**

1. John J. Craig, Introduction to Robotics Mechanics and Control, Prentice-Hall, 3rd Edition, 2004.
2. M.W. Spong, S. Hutchinson and M. Vidyasagar, "Robot modeling and control," John Wiley and Sons, First Edition, 2005.
3. Norman S.Nise, "Control Systems Engineering", John Wiley and Sons, 6th Edition, 2010.

9. References

1. Richard D. Klafter, Thomas. A Chri Elewski, Michael Negin, Robotics Engineering an Integrated Approach, Prentice-Hall, 1989.
2. Frank L. Lewis, Chaouki T. Abdallah, D. M. Dawson, "Robot manipulator control: theory and practice", CRC Press, 2nd Edition, 2003.

COURSE CODE	MICROPROCESSOR AND MICROCONTROLLER	L	T	P	C
10212ME145		3	0	0	3

1. Preamble

This course provides the learners to learn about the inception of microprocessor and microcontroller, their configuration, interfacing, programming. And to learn about the working of peripheral devices along with plc programming.

2. Pre-requisite

10210CS101 -Problem Solving using C

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- To gain knowledge on microprocessor, its architecture and pin configuration
- To be able to understand the working of microcontroller, it's architecture and interfacing
- To acquire the knowledge on 8051 microcontroller programming
- To understand the peripheral devices associated with microprocessor and controller
- To identify the working of PLA and applications of mechatronics.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Explain the architecture and working of 8085 microprocessor and its associated functions.	K2
CO2	Describe the operating principle of 8051 microcontroller and its interfacing provisions.	K2
CO3	Develop C and assembly language programme using 8051 microcontroller for the given conditions	K3
CO4	Describe the 8255 architecture along with timer, counters and interrupt controllers.	K2
CO5	Explain the PLC and the applications of microcontrollers	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M											L	
CO2	H	M											L	
CO3	H	H	M										L	
CO4	H	M											L	
CO5	H	M											L	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I 8085 MICROPROCESSOR

L-9

Introduction to microprocessor, Architecture of 8085, Pin configuration, Addressing modes, Instruction set, Timing diagram, I/O interfacing, Assembly language programming, Recent upgrades in microprocessor (Architecture of PIC, ARM, ATMEGA processors).

UNIT II 8051 MICROCONTROLLER**L-9**

Introduction to microcontroller, Architecture of 8051, I/O ports & circuits, Timers, Interrupts, Serial communication, Keyboard & LCD interfacing, External memory interfacing.

UNIT III 8051 PROGRAMMING**L-9**

Addressing modes, Instruction set, Assembly language programming and C Programming, Timer counter programming, Serial communication programming, Interrupt Programming.

UNIT IV PROGRAMMABLE PERIPHERAL DEVICES**L-9**

Introduction to PPI, Architecture of 8255, Timer & Counter (8253), Keyboard & Display Controller (8279), USART (8251), Interrupt Controller (8259), DMA Controller (8237).

UNIT V PLC AND APPLICATIONS OF MICROCONTROLLER**L-9**

Introduction to PLC, Basic structure, Input and output processing, Programming, Mnemonics, Timers, counters and internal relays, Programming the PLC using Ladder diagram, Temperature control system, Motor speed control system, Data Acquisitions system.

TOTAL: 45 PERIODS**8. Text Books**

1. Ramesh S Gaonkar, Microprocessor Architecture, Programming and application with 8085, 6th Edition, Penram International Publishing.
2. W. Bolton, Electronic Control Systems in Mechanical and Electrical Engineering, Prentice Hall, New Delhi, 2003.
3. Muhammad Ali Mazidi, Janice GillispieMazidi and Rolin D McKinlay, "The 8051 microcontroller and embedded systems using assembly and C", second edition Pearson education Asia.

9. References

1. Kenneth J Ayala, The 8051 Microcontroller Architecture Programming and Application, third Edition, Penram International Publishers.
2. A.K Ray & K.M. Burchandi, Advanced Microprocessor and peripherals Architectures, Programming and interfacing ", second edition, Tata McGraw-Hill.
3. David W. Pessen, Industrial Automation Circuit Design and Components, John Wiley, New York, 1990.
4. James Harter, Electromechanics, Principles and Concepts and Devices, Prentice Hall, New Delhi, 2003.

COURSE CODE	SENSORS AND ACTUATORS FOR ROBOTICS	L	T	P	C
10212ME146	OPERATION	3	0	0	3

1. Preamble

This course provides the classification of sensors and their real time application along with their association with micro actuator, micro sensor and microbotics.

2. Pre-requisite

NIL

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the classification and working sensor and its applications.
- Understand the concept of micro actuator, micro sensor and microbotics.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Classify the types of internal sensors used in robots for industrial applications	K3
CO2	Classify the types of external sensors used in robots for industrial applications	K3
CO3	Explain the use of vision based sensors for image analysis	K2
CO4	Explain the types and working of actuators and micro actuators	K2
CO5	Describe the working and applications of micro sensors and microbotics.	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M											M	
CO2	H	M	L										M	L
CO3	H	M											M	
CO4	H	M											M	
CO5	H	M											M	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTERNAL SENSORS

L-9

Introduction, Requirement of a sensors in robots used in various industries, Static and dynamic characteristics, Performance measures of sensors, Classification of sensors, Internal sensors - Position sensors, Encoders, Potentiometers, LVDTs, velocity sensors, Tacho generator, Hall effect sensor, Acceleration sensors, Heading sensors- Compass, Gyroscope sensor, IMU, GPS, real time differential GPS, Force sensors, strain gauge based & Piezo electric based, Torque sensors, Interpreting typical manufacturer's data sheet of internal sensors.

UNIT II EXTERNAL SENSORS**L-9**

Contact type, noncontact type, Tactile, proximity detection of physical contact or closeness, contact switches, bumpers , inductive proximity, capacitive proximity; semiconductor displacement sensor; Range sensors- IR, sonar, laser range finder, optical triangulation (1D), structured light (2D), performance comparison range sensors; motion/ speed sensors-speed relative to fixed or moving objects, Doppler radar, Doppler sound; Interpreting typical manufacturer's data sheet of external sensors.

UNIT III VISION BASED SENSORS**L-9**

Elements of vision sensor, image acquisition, image processing, edge detection, feature extraction, object recognition, pose estimation and visual servoing, hierarchy of a vision system, CCD and CMOS Cameras, Monochrome, stereovision, night vision cameras, still vs video cameras, kinect sensor.

UNIT IV ACTUATORS AND MICROACTUATORS**L-9**

Actuators: Electrical, Hydraulic and Pneumatic. Micro Actuators: Actuation principle, shape memory effects-one way, two way and pseudo elasticity. Types of micro actuators- Electrostatic, Magnetic, Fluidic, Inverse piezo effect, other principles.

UNIT V MICROSENSORS AND MICROBOTICS**L-9**

Micro Sensors: Principles and examples, Force and pressure micro sensors, position and speed micro sensors, acceleration micro sensors, chemical sensors, biosensors, temperature micro sensors and flow micro sensors. Microbotics: Drive principle, classification, and application, micro assembly with the help of microbots, flexible microbots, and Automated desktop station using micromanipulation robots.

TOTAL: 45 PERIODS**8. Text Books**

1. Patranabis D., " Sensor and Actuators", Prentice Hall of India (Pvt) Ltd., 2005.
2. Robotics Engineering: An Integrated Approach, by Richard D. Klafter, Prentice Hall Inc.
3. Sergej Fatikow and Ulrich Rembold, Microsystem Technology and Microbotics First edition, Springer – Verlag Newyork, Inc, 1997.

9. References

1. Renganathan S., " Transducer Engineering", Allied Publishers (P) Ltd., 2003.
2. Clarence W. de Silva, Sensors and Actuators: Control System Instrumentation, CRC Press 2007, ISBN-13: 978-1420044836
3. Introduction to Robotics, S K Saha, Mc Graw Hill Eduaction Massood Tabib and Azar, Microactuators Electrical, Magnetic, thermal, optical, mechanical, chemical and smart structures , First edition, Kluwer academic publishers, Springer.

COURSE CODE	DESIGN OF ROBOT WITH ARTIFICIAL INTELLIGENCE	L	T	P	C
10212ME147		3	0	0	3

1. Preamble

This course is designed to provide knowledge about the concepts of various tools and approaches available for product design and process development.

2. Pre-requisite

NIL

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Get a complete idea about the robot design point of view from the structural design to the operation of the robot for different applications.
- Importance and application of AI in robot design and operation.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Explain the different types of robots and its design procedure	K2
CO2	Explain different types of control system for the design of robot.	K2
CO3	Develop main structures of robot and its parts	K3
CO4	Choose actuating systems for the design of robot.	K3
CO5	Describe the importance and implementation of Artificial intelligence in robot	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	L											H	L
CO2	H	H	L			L		L					H	L
CO3	H	H	L			L		L					H	L
CO4	H	L											H	L
CO5	H	L	L			L		L				L	H	L

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I DESIGN THINKING OF ROBOT

L-9

Design concept - Mobile robot - Fixed robot - Humanoid robot - Industrial robot
- Aerial robot - Underwater robot.

UNIT II DESIGN OF CONTROL SYSTEM

L-9

Basic control system - Control components - Control software - Differential motion – Navigation - Path planning.

UNIT III DESIGN OF MAIN STRUCTURES

L-9

DH parameters - End effector design - Legged robot - Multi-fingered Robot – Manipulators.

UNIT IV DESIGN OF DRIVES AND ACTUATOR**L-9**

Identify the requirements - Robot actuation and feedback - Coordinate transformation - Rotational transformation - Kinematics and inverse kinematics - Trajectory design and configuration space - Motion planning.

UNIT V DESIGN OF ROBOT WITH ARTIFICIAL INTELLIGENCE**L-9**

Humanoid Needs of AI - Implementation of AI - Application of commercial robot with AI - Application of industrial robot with AI - Case: One robot with AI.

TOTAL: 45 PERIODS**8. Text Books**

1. John J. Craig, Introduction to Robotics Mechanics and Control, Prentice-Hall, 3rd Edition, 2004.
2. M.W. Spong, S. Hutchinson and M. Vidyasagar, "Robot modeling and control," John Wiley and Sons, First Edition, 2005.
3. Norman S.Nise, "Control Systems Engineering", John Wiley and Sons, 6th Edition, 2010.

9. References

1. Richard D. Klafter, Thomas. A Chri Elewski, Michael Negin, Robotics Engineering an Integrated Approach, Prentice-Hall, 1989.
2. Frank L. Lewis, Chaouki T. Abdallah, D. M. Dawson, "Robot manipulator control: theory and practice", CRC Press, 2nd Edition, 2003.

COURSE CODE	DYNAMICS AND KINEMATICS OF ROBOTS	L	T	P	C
10212ME148		3	0	0	3

1. Preamble

This course helps the student to learn the basics of a Robot. Students are introduced to the basic design consideration of robots. Concepts of Dynamics and Kinematics of robots are introduced.

2. Pre-requisite

NIL

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the dynamic and kinematics motions of robots.
- Understand the design considerations, differential motion and force analysis.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Explain the kinematics of robots	K2
CO2	Discuss the working of inverse kinematics of different axis robots.	K2
CO3	Describe the workspace analysis for robots and its associated fixtures.	K2
CO4	Discuss about the tool configuration and manipulator concepts of jacobian matrix for robots.	K2
CO5	Discuss the theories of Lagrangian mechanics, trajectory planning and various motions.	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L										L	L	
CO2	M	L										L	L	
CO3	M	L										L	L	
CO4	M	L										L	L	
CO5	M	L										L	L	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I DIRECT KINEMATICS

L-9

Dot and cross products, Co-ordinate frames, Rotations, Homogeneous Coordinates, Link coordinates, D-H Representation, Arm equation -Two axis, three axis, four axis, five axis and six axis robots.

UNIT II INVERSE KINEMATICS

L-9

General properties of solutions, Tool configuration, Inverse Kinematics of Two axis, Three axis, Four axis and Five axis robots.

UNIT III WORKSPACE ANALYSIS**L-9**

Workspace analysis of Four axis, Five axis and Six axis robots, Perspective transformation, Structured illumination, Camera calibration, Work envelope of Four and Five axis robots, Workspace fixtures.

UNIT IV DIFFERENTIAL MOTION AND STATICS**L-9**

The tool Configuration jacobian matrix for three axis and four axis robots, joint space singularities, resolved motion rate control, manipulator jacobian for three and four axis joint space singularities, induced joint torques and forces.

UNIT V DYNAMIC ANALYSIS AND FORCES**L-9**

Introduction, Langrangian mechanics, Effects of moments of Inertia, Dynamic equation for two axis planar articulated robot. Trajectory planning, Pick and place operations, Continuous path motion, Interpolated motion, Straight line motion.

TOTAL: 45 PERIODS**8. Text Books**

1. Robert J. Schilling, —Fundamentals of Robotics Analysis and Control , PHI Learning, 2009.
2. Niku S B, —Introduction to Robotics, Analysis, Systems, Applications , Prentice Hall, 2001

9. References

1. John J Craig, —Introduction to Robotics , Pearson, 2009.
2. Deb S R and Deb S, —Robotics Technology and Flexible Automation , Tata McGraw Hill Education Pvt. Ltd, 2010.
3. Richard D Klafter, Thomas A Chmielewski, Michael Negin, "Robotics Engineering – An Integrated Approach", Eastern Economy Edition, Prentice Hall of India P Ltd., 2006.
4. Saha S K, —Introduction to Robotics , Tata McGraw Hill Education Pvt. Ltd, 2010.

COURSE CODE	APPLICATIONS OF ROBOTS	L	T	P	C
10212ME149		3	0	0	3

1. Preamble

This course is designed to provide knowledge about the concepts of various tools and approaches available for product design and process development.

2. Pre-requisite

NIL

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the application of robots in different industries for different applications.
- Explore the opportunity to use robotic technology for different purposes.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Discuss the use of robot for industrial, home, rescue, customer care and underwater applications	K2
CO2	Identify and explain the constructional details and functions of robot for defense applications.	K2
CO3	Identify and explain the constructional details and functions of robot for industrial applications.	K2
CO4	Identify and explain the constructional details and functions of robot for educational applications.	K2
CO5	Identify and explain the constructional details and functions of robot for process automation.	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	H					L						H	
CO2	M	H	L				L	L					H	L
CO3	M	H	L				L	L					H	L
CO4	M	H	L				L	L					H	L
CO5	M	H	L				L	L					H	L

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I SERVICE ROBOT

L-9

Application robot (sectors) - Home applications - Rescue operation - Customer care- Underwater robot.

UNIT II ROBOTICS FOR DEFENCE

L-9

Outer space applications - Unmanned aerial vehicle - Unmanned ground vehicle - Autonomous underwater vehicle - Humanoid robot shoulders.

UNIT III INDUSTRIAL SECTOR**L-9**

Manufacturing industry - Agricultural applications - Health/Medical services - Food preparation - Industrial automation.

UNIT IV EDUCATION**L-9**

Application robot in education – Simulations - Robotics kits and programming applications – Entertainment.

UNIT V ROBOTIC PROCESS AUTOMATION**L-9**

Scope and technique of automation - Robotic process automation - Components of RPA - Record and play - Sequence, flow chart, and control flow - Application of RPA.

TOTAL: 45 PERIODS**8. Text Books**

1. John J. Craig, Introduction to Robotics Mechanics and Control, Prentice-Hall, 3rd Edition, 2004.
2. M.W. Spong, S. Hutchinson and M. Vidyasagar, "Robot modeling and control," John Wiley and Sons, First Edition, 2005.
3. Norman S.Nise, "Control Systems Engineering", John Wiley and Sons, 6th Edition, 2010.

9. References

1. Richard D. Klafter, Thomas. A Chri Elewski, Michael Negin, Robotics Engineering an Integrated Approach, Prentice-Hall, 1989.
2. Frank L. Lewis, Chaouki T. Abdallah, D. M. Dawson, "Robot manipulator control: theory and practice", CRC Press, 2nd Edition, 2003.

COURSE CODE	MICROPROCESSOR AND MICROCONTROLLER	L	T	P	C
10212ME150		3	0	0	3

1. Preamble

The Purpose of the course is to provide students with the Knowledge of Microprocessors and Microcontroller. To solve real world problems in an efficient manner, this course also emphasis on architecture, Programming and system design used in various day to day gadgets.

2. Pre-requisite

NIL

3. Link to the other courses

10211ME207 -Mechatronics

4. Course Educational Objectives

Students, after undergoing this course would

- Gain knowledge on the basic concepts of Microprocessor and Microcontroller.
- Understand the concept of embedded systems.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Develop an assembly language programme using 8085 microprocessor for the given design specifications	K3
CO2	Describe the architecture and functional block of 8051 microcontroller	K2
CO3	Develop an embedded C and assembly language programme using 8051 microcontroller for the given design specifications	K3
CO4	Describe various peripherals devices (8255, 8279, 8251, 8253, 8259 and 8237) of microprocessors and microcontrollers	K2
CO5	Explain the applications and architecture of PIC, ARM and ATMEGA processors and microcontrollers.	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	H		H			H				H	H	H
CO2	M	H											H	
CO3	H	H	H		H			H				H	H	H
CO4	M	H											H	L
CO5	M	M											M	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I 8085 CPU

L-9

8085 Architecture – Pin diagram-Memory interfacing – I/O interfacing- Timing Diagram- Instruction Set- Addressing modes – Assembly language programming- 8086 Architecture, comparison of 8 bit (8085) and 16 bit (8086)processors.

UNIT II 8051 ARCHITECTURE**L-9**

Architecture – memory organization –I/O ports and circuits-Timers - Interrupts –serial communication - Interfacing of External memory-Interfacing LCD & Keyboard-RTC.

UNIT III 8051 PROGRAMMING**L-9**

Addressing modes -instruction set -Assembly language programming and C Programming– Timer Counter Programming – Serial Communication Programming- Interrupt Programming.

UNIT IV PERIPHERAL DEVICES**L-9**

Parallel peripheral Interface (8255) - Timer / Counter (8253) - Keyboard and Display Controller (8279) - USART (8251) - Interrupt Controller (8259)- DMA Controller (8237).

**UNIT V MICROCONTROLLER APPLICATIONS & ADVANCED L-9
PROCESSOR**

Temperature control system- Motor speed control system – Traffic light System – Elevator system-Data Acquisitions system - Introduction to architecture of PIC, ARM, ATMEGA processors.

TOTAL: 45 PERIODS**8. Text Books**

1. Ramesh S Gaonkar, Microprocessor Architecture, Programming and application with 8085, 6th Edition, Penram International Publishing.
2. Muhammad Ali Mazidi, Janice GillispieMazidi and Rolin D McKinlay, The 8051 microcontroller and embedded systems using assembly and C, second edition Pearson education Asia.
3. Mohamed Rafiquzzaman, Microprocessor and Microcomputer based system design, second edition, and CRC press.

9. References

1. Kenneth J Ayala, the 8051 Microcontroller Architecture Programming and Application, third Edition, Penram International Publishers.
2. A.K Ray & K.M. Burchandi, Advanced Microprocessor and peripherals Architectures, Programming and interfacing “, second edition, Tata McGraw-Hill.

COURSE CODE	EMBEDDED SYSTEM AND DEVICE DRIVERS	L	T	P	C
10212ME151		3	0	0	3

1. Preamble

The Purpose of the course is to provide students with the basic knowledge of embedded operating systems and device drivers. This course emphasizes knowledge on operating system used in embedded system.

2. Pre-requisite

NIL

3. Link to the other courses

10211ME207 -Mechatronics

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the concepts related RTOS and embedded systems.
- Understand the basic techniques in embedded systems.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Explain the structure of operating system and develop codes to create process and task	K3
CO2	Explain different synchronization mechanisms used in RTOS and develop small codes to demonstrate synchronization concepts	K3
CO3	Explain different boot loaders technique used in embedded system	K2
CO4	Describe the kernel memory optimization techniques used in embedded system	K2
CO5	Develop codes for embedded system device drivers using Linux language	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	L		M	M		M				L	H	M
CO2	H	H	L		M	M		M				L	H	M
CO3	M	M											M	L
CO4	M	M											M	L
CO5	H	H	L		M	M		M				L	H	M

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION TO OPERATING SYSTEMS

L-9

Basic Principles -Operating System structures –System Calls –Files –Processes –Design and Implementation of processes –Communication between processes –Introduction to Distributed operating system –Issues in distributed system: states, events, Clocks-Distributed Scheduling-Fault & recovery.

UNIT II OVERVIEW OF RTOS**L-9**

RTOS Task and Task state –Multithreaded Preemptive Scheduler-Process Synchronization-Message queues–Mail boxes -pipes –Critical section –Semaphores –Classical synchronization problem –Deadlocks.

UNIT III BOOT LOADERS**L-9**

Board Support Packages: Inserting BSP in Kernel Build Procedure- Boot loader Interface–Memory Map –Interrupt Management-PCI Subsystem –Timers-UART- Power Management, Embedded Storage –MTD – MTD Architecture-MTD Driver for NOR Flash- Flash Mapping Driver -Embedded File Systems.

UNIT IV EMBEDDED KERNEL & DEVICE DRIVERS**L-9**

Embedded Kernel: Optimizing storage Space-Tuning kernel memory

Embedded Drivers: Embedded Systems Model and Device Drivers–Classes of Devices Building reusable device drivers for microcontrollers, Ethernet Driver-I2C Subsystem, Watchdog Timer – Kernel Modules.

UNIT V LINUX DEVICE DRIVERS**L-9**

Modules-Building and Running Modules, Linux Serial Driver, I2C Subsystem on Linux-USB Gadgets Debugging Techniques-Concurrency and its Management-Semaphores & Mutexes.

TOTAL: 45 PERIODS**8. Text Books**

1. Raj Kamal, “Embedded Systems -Architecture, Programming and Design” Tata McGraw Hill,2006.
2. P. Raghavan, Amol Lad, Sriram Neelakandan “Embedded Linux System Design and Development” Auerbach Publications 2005.

9. References

1. Jonathan Corbet, AlessandroRubini& Greg Kroah-Hartman “Linux Device Drivers” O’Rielly 3rd Edition 2005.
2. Silberschatz, Galvin, Gagne” Operating System Concepts, 6th edition, John Wiley,2003Jindal U.C. “Strength of Materials” Asian Books Pvt Ltd, New Delhi 2007.

COURSE CODE	SENSORS AND ACTUATORS	L	T	P	C
10212ME152		3	0	0	3

1. Preamble

This course provides the concept of sensor and how to interface the sensor in real time system with the concept of micro actuator, micro valves, micro sensor and microbots.

2. Pre-requisite

NIL

3. Link to the other courses

10211ME207 -Mechatronics

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the various types of sensor and its application.
- Understand the concept of micro actuator, micro valves, micro sensor and microbots.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Choose appropriate method and instrument for linear and angular measurement	K3
CO2	Apply laser and advanced instruments to measure the straightness, flatness, and roundness of given engineering components	K3
CO3	Explain the principle and applications of sensors for metrological inspection	K2
CO4	Illustrate the types and working principle of micro actuators and micro valves	K3
CO5	Illustrate the types, applications, and working principle of micro sensors and microbotics	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H			M	L							H	H
CO2	H	H			M	L						M	H	H
CO3	H	M											M	
CO4	H	H											M	
CO5	H	H											M	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I LINEAR AND ANGULAR MEASUREMENTS

L-9

General concepts of measurements – Definition, Standards of measurement – Errors in measurement, Accuracy, Precision. Length standard – Line and end standard – Slip gauges, Micrometers, Vernier, Dial gauges – comparators, types, principle and applications – interferometry – Angular measuring instruments – bevel protractor, levels, clinometers – Sine bar, angle dekkor – auto collimator.

UNIT II FORM MEASUREMENTS AND COMPUTER AIDED METROLOGY L-9

Straightness, Flatness and roundness measurement, surface finish measurements, Tool makers microscope, various elements of threads – 2 wire and 3 wire methods – gear elements – various errors and measurements. Co-ordinate measuring machine – construction features – types – application of CMM – Computer aided inspection – Machine vision – Non contact and in-process inspection, Laser Interferometer and its application.

UNIT III SENSOR L-9

Principles and Applications of displacement sensor – position sensors, linear and angular – velocity sensors – Torque sensors. Principle and applications of pressure sensor, flow sensors, temperature sensors, acoustic sensor and vibration sensors.

UNIT IV MICRO ACTUATORS AND MICRO VALVES L-9

Micro Actuators: Actuation principle, shape memory effects-one way, two way and pseudo elasticity. Types of micro actuators- Electrostatic, Magnetic, Fluidic, Inverse piezo effect, other principles.

Micro valves: Electromagnetic, Piezoelectric, Electrostatic, Thermo pneumatic, Bimetal. Linear actuators-magnetic, electrostatic, piezoelectric.

UNIT V MICRO SENSORS AND MICROBOTICS L-9

Micro Sensors: Principles and examples, Force and pressure micro sensors, position and speed micro sensors, acceleration micro sensors, chemical sensors, biosensors, temperature micro sensors and flow micro sensors.

Microbotics: Drive principle, classification, application, micro assembly with the help of microbots, flexible microbots, and Automated desktop station using micromanipulation robots.

TOTAL: 45 PERIODS

8. Text Books

1. Jain .R. K., Engineering Metrology, Khanna Publishers, 1994.
2. Patranabis.D, Sensors and Transducers, Wheeler publisher, 1994.
3. Sergej Fatikow and Ulrich Rembold, Microsystem Technology and Microbotics First edition, Springer –Verlag NEwYork, Inc, 1997.

9. References

1. Gupta. I.C., A Text book of Engineering Metrology, Dhanpat Rai and Sons, 1996.
2. ASTE Hand Book of Industries Metrology, Prentice Hall of India, 1992.
3. Thomas. G. Bekwith and Lewis Buck.N, Mechanical Measurements, Oxford and IBH publishing Co. Pvt. Ltd.,
4. Massood Tabib and Azar, Microactuators Electrical, Magnetic, thermal, optical, mechanical, chemical and smart structures , First edition, Kluwer academic publishers, Springer,1997.
5. Manfred Kohl, Shape Memory Actuators, first edition, Springer.

COURSE CODE	DRIVES AND CONTROLS FOR AUTOMATION	L	T	P	C
10212ME153		3	0	0	3

1. Preamble

This course provides various concepts of Drives used in automation industry for the continuous process.

2. Pre-requisite

NIL

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the concept of DC, Synchronous motor and induction motor drive used in automation.
- Understand the concept of how to control the various types of drives.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Select motor power rating and drive specifications for automation	K3
CO2	Analyze the performance of DC motor drives used in automation	K4
CO3	Analyze the performance of induction motor drives used in automation	K4
CO4	Analyze the performance of synchronous motor drives used in automation	K4
CO5	Select suitable drive control for steel rolling mills, paper mills, lifts and cranes application.	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H											H	
CO2	H	H	M										H	L
CO3	H	H	M										H	L
CO4	H	H	M										H	L
CO5	H	H										M	H	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION

L-9

Introduction to drives – Selection of Motor power rating – Drive specifications – Constant speed and constant power operation.

UNIT II DC DRIVE

L-9

DC motor and their performance – Armature control and Field control - Ward Leonard drives – converter fed and chopper fed Drive – four quadrant operation – closed loop control.

UNIT III INDUCTION MOTOR DRIVE**L-9**

Induction motor fundamentals – voltage control and variable frequency control (AC chopper, Inverter fed induction motor drives). – Rotor resistance control – slip power recovery scheme.

UNIT IV SYNCHRONOUS MOTOR DRIVE**L-9**

Synchronous motor fundamentals – open loop, closed loop variable frequency control – voltage and current source fed synchronous motor.

UNIT V DRIVE CONTROLS**L-9**

Digital technique in speed control – Advantages and limitations – Microprocessor based control of drives – Selection of drives and control schemes for steel rolling mills, paper mills, lifts and cranes.

TOTAL: 45 PERIODS**8. Text Books**

1. Dubey G.K., Fundamental of Electric Drives, Narosa publishing house 1995.
2. Pillai S.K., A first course on Electrical Drives, New Age International (p) Ltd., 1984.

9. References

1. Dubey G.K. *“Power Semiconductor Controlled Drives*, Narosa publishing house 1995.
2. Vedam Subramanian *Thyristor Control of Electrical Drives* Tata Mc Graw Hill Publications, 1996.

COURSE CODE	INDUSTRIAL ROBOTICS	L	T	P	C
10212ME154		3	0	0	3

1. Preamble

This course provides an introduction to the robots types, Laws, configurations and application; Co-ordinate frames and types, Transformations and types; Forward and Inverse Kinematics of manipulator's; all types of robotic sensors; Open loop and closed loop control systems with examples.

2. Pre-requisite

NIL

3. Link to the other courses

10211ME207 -Mechatronics

Project Work

4. Course Educational Objectives

To understand an overview of robotics in practice and research with topics including control systems, motion planning, mobile mechanisms, kinematics, inverse kinematics, and sensors.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Classify robot configuration, drives, motion, and control path.	K3
CO2	Describe kinematics and dynamics of robot components and its operations.	K2
CO3	Discuss the use of sensing and visioning operations systems in industrial robotics	K2
CO4	Describe the languages, and search techniques used in robot programming.	K2
CO5	Express the industrial applications of robots	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	H											H	
CO2	M	M											H	M
CO3	M	M											H	
CO4	H	H	M		M			H					H	H
CO5	M	M											H	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION

L-9

Definition of a Robot - Basic Concepts - Robot configurations - Types of Robot drives - Basic robot motions -Point to point control - Continuous path control.

UNIT II COMPONENTS AND OPERATIONS**L-9**

Basic control system concepts - control system analysis - robot actuation and feedback, Manipulators – direct and inverse kinematics, Coordinate transformation - Brief Robot dynamics. Types of Robot and effectors - Grippers - Tools as end effectors - Robot/End - effort interface.

UNIT III SENSING AND MACHINE VISION**L-9**

Range sensing - Proximity sensing - Touch sensing - Force and Torque sensing. Introduction to Machine vision - Sensing and digitizing - Image processing and analysis.

UNIT IV ROBOT PROGRAMMING**L-9**

Methods - languages - Capabilities and limitation - Artificial intelligence - Knowledge representation – Search techniques - AI and Robotics.

UNIT V INDUSTRIAL APPLICATIONS**L-9**

Application of robots in machining - Welding - Assembly - Material handling - Loading and unloading – CIM - Hostile and remote environments.

TOTAL: 45 PERIODS**8. Text Books**

1. John J. Craig, Introduction to Robotics Mechanics and Control, Prentice Hall, 3rd Edition, 2004.
2. M.W. Spong, S. Hutchinson and M. Vidyasagar, "Robot modeling and control," John Wiley and Sons, First Edition, 2005.
3. Norman S.Nise, "Control Systems Engineering", John Wiley and Sons, 6th Edition, 2010.

9. References

1. Richard D. Klafter, Thomas. A, Chri Elewski, Michael Negin, Robotics Engineering an Integrated Approach, Prentice Hall, 1989.
2. Frank L. Lewis, Chaouki T. Abdallah, D. M. Dawson, "Robot manipulator control: theory and practice", CRC press, 2nd Edition, 2003.

COURSE CODE	AUTOMOTIVE ELECTRONICS	L	T	P	C
10212ME155		3	0	0	3

1. Preamble

This course provide the concept of various automotive electronic component system working such as electronic fuel injection, digital engine control system, vehicle motion control and stabilization systems.

2. Pre-requisite

NIL

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the concept of open and closed loop systems.
- Understand the various concept of automotive electronics system.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Compare open and closed loop systems and explain the use of electronic systems in engine management.	K3
CO2	Illustrate the use of sensors and actuators for crank angle position and fuel metering.	K3
CO3	Discuss the types, components, working, and advantages of electronic fuel injection and ignition systems.	K2
CO4	Illustrate the use of digital control systems for engine cranking, speed control, and ignition	K3
CO5	Explain the use of electronic systems in vehicle motion and stabilization systems.	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	H					H						M	L
CO2	M	M					H						M	M
CO3	L	M					H						M	M
CO4	M	M											M	M
CO5	L	M											M	M

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I FUNDAMENTAL OF AUTOMOTIVE ELECTRONICS

L-9

Current trend in Automobiles. Open loop and closed loop systems -Components for electronic engine management. Electronic management of chassis system.

UNIT II SENSORS AND ACTUATORS

L-9

Introduction, basic sensor arrangement, types of sensors such as -oxygen sensors, Crank angle position sensors - Fuel metering, vehicle speed sensor and detonation sensor -Altitude sensor, flow sensor. Throttle position sensors, solenoids, stepper motors, relays.

UNIT III ELECTRONIC FUEL INJECTION AND IGNITION SYSTEMS

L-9

Introduction, Feedback carburetor systems (FBC), Throttle body injection and multi point fuel injection, Fuel injection systems, injection system controls. Advantages of electronic ignition system. Types of solid-state ignition systems and their principle of operation, Contact less electronic ignition system, Electronic spark timing control.

UNIT IV DIGITAL ENGINE CONTROL SYSTEM

L-9

Open loop and closed loop control systems -Engine cranking and warm up control - Acceleration enrichment - Deceleration leaning and idle speed control. Distributor-less ignition -Integrated engine control system, Exhaust emission control engineering.

UNIT V VEHICLE MOTION CONTROL AND STABILIZATION SYSTEMS

L-9

Vehicle motion control - Adaptive cruise control, Electronic transmission control. Vehicle stabilization system - Antilock braking system, Traction control system, Electronic stability program. Onboard diagnosis system.

TOTAL: 45 PERIODS

8. Text Books

1. William B.Riddens, Understanding Automotive Electronics, 5th Edition, Butterworth, Heinemann Woburn, 1998.
2. Tom Weather Jr and Cland C.Hunter, Automotive Computers and Control system, Prentice Hall Inc., New Jersey.
3. BOSCH, Automotive Handbook, 6th Edition, Bentley publishers.

9. References

1. Young. A.P. and Griffths.L. *Automobile Electrical Equipment*, English Language Book Society and New Press.
2. Crouse.W.H., *Automobile Electrical equipment*, McGraw Hill Book Co Inc., New York, 1955.
3. Robert N Brady., *Automotive Computers and Digital Instrumentation*, A Reston Book. Prentice Hall, Eagle Wood Cliffs, New Jersey, 1988.
4. Bechtold., *Understanding Automotive Electronics*, SAE, 1998.

COURSE CODE	MICRO ELECTRO MECHANICAL SYSTEMS	L	T	P	C
10212ME156		3	0	0	3

1. Preamble

This course provides an introduction to various Micro electro mechanical device and Study about the principles of micro sensors, valves, pumps used in Microsystems.

2. Pre-requisite

NIL

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the various Micro electro mechanical device
- Create confidence in the study of various Microsystems.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Express the use of scaling laws and materials in the conceptual design of micro-devices.	K2
CO2	Choose a fabrication process suitable for production of a MEMS device	K3
CO3	Choose a micromachining technique for a specific MEMS fabrication process.	K3
CO4	Illustrate the working principle of micro-sensors, actuators, valves, pumps, and fluidics used in Microsystems	K3
CO5	Describe packaging, process design and applications of micro system in automotive, bio medical, aerospace, and telecommunication industries	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	M											M	
CO2	H	H	L				L	L					H	M
CO3	H	H	L				L	L					H	M
CO4	M	M											H	
CO5	L	L											M	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION TO MEMS

L-9

Introduction to MEMS: Introduction to Microsystems and microelectronics - Market scenario for MEMS. Working principle: Trimmers scaling vector and scaling laws - scaling in geometry - scaling in rigid body dynamics- scaling in electrostatic forces - scaling in electricity - scaling in fluid mechanics - scaling in heat transfer. Materials for MEMS: Silicon as a MEMS material - Crystal structure of silicon - Miller indices - silicon compounds - SiO₂, SiC, Si₃N₄ and polycrystalline silicon - silicon piezo-resistors - Gallium arsenide - polymers for MEMS -quartz.

UNIT II FABRICATION OF MEMS**L-9**

Clean room technology - Substrates and wafer - single crystal silicon wafer formation - ideal substrates - mechanical properties - Processes for bulk micromachining - Wet Vs dry etching - Chemical etching of Silicon - etchant systems and etching process - Reactive ion etching and DRIE - mask layout design. Processes for Surface micromachining - Deposition processes - ion implantation - Diffusion - oxidation - chemical vapor deposition - physical vapor deposition - deposition by epitaxy - photolithography and photoresists. Limitations of Bulk and surface micromachining - LIGA, SLIGA and other micromolding processes such as HeXIL.

UNIT III DESIGN CONSIDERATIONS BASED ON MICROMECHANICS**L-9**

Micromechanics considerations - static bending of thin plates - circular plates with edge fixed - rectangular plate with all edges fixed - square plate with all edges fixed - mechanical vibration - resonant vibration - micro accelerometers - design theory and damping coefficients - thermo mechanics - thermal stresses - fracture mechanics - stress intensity factors - fracture toughness - and interfacial fracture mechanics

UNIT IV MEMS DEVICES**L-9**

Micro actuation techniques - piezoelectric crystals - Shape memory alloys - bimetallics - conductive polymers. Micro motors - micro grippers - Microfluidic devices - Micro pumps - mechanical and nonmechanical micropumps - micro valves - valveless micropumps - Lab on Chip. Types of micro sensors - Microaccelerometer - Micropressure sensors, MEMS switches/resonators, MEMS reliability.

UNIT V MICROSYSTEM PACKAGING AND DESIGN**L-9**

Micro system packaging - materials die level device level - system level - packaging techniques - die preparation - surface bonding - wire bonding - sealing - Case studies. Design considerations - process design - mechanical design - applications of micro system in automotive - bio medical - aerospace - telecommunication industries.

TOTAL: 45 PERIODS**8. Text Books**

1. Mohamed Gad-el-Hak, The MEMS Handbook, CRC Press Publishers, India, 2002
2. Tai Ran Hsu, MEMS and Micro Systems Design and Manufacture, Tata McGraw-Hill Publishing Company Ltd, New Delhi, 2008
3. Nadim Maluf, An Introduction to Micro Electro Mechanical System Design, Artech House Publishers, London, 2004.

9. References

1. Chang Liu, Foundations of MEMS, Pearson Education, New Delhi, 2011. James J. Allen, Micro Electro Mechanical System Design, CRC Press Publishers, India, 2005
2. Julian w. Gardner, Vijay K. Varadan and Osama O. Awadelkarim, Micro sensors MEMS and smart Devices, John Wiley and Sons Ltd., England, 2002
3. E.H. Tay, Francis and W.O.Choong, Microfluids and Bio MEMS applications, Springer, 2002
4. Bhusan, Bharat (Ed), "Springer Handbook of Nanotechnology", 2nd Edition, 2007.

COURSE CODE	FACTORY AUTOMATION	L	T	P	C
10212ME157		3	0	0	3

1. Preamble

This course provide the concept of various production, manufacturing, group technology, flexible manufacturing systems, material handling system and computer integrated manufacturing system .

2. Pre-requisite

NIL

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the production and manufacturing system automation
- Understand the computer control system and material handling system.
- Understand the concept of computer integrated manufacturing systems.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Explain the basic elements of automated systems and hardware requirements for automation.	K2
CO2	Illustrate the OPTIZ and MI-CLASS coding methods and the components of flexible manufacturing systems	K3
CO3	Illustrate the structure and characteristics of network systems and computer aided process planning.	K3
CO4	Identify suitable material handling equipment for automated storage systems.	K2
CO5	Explain the structure, components and functional areas of the computer integrated manufacturing system	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M												M	
CO2	H	H	M		M	M		M				L	H	H
CO3	H	H											H	H
CO4	M	H											M	
CO5	M												M	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I PRODUCTION OPERATIONS AND AUTOMATION STRATEGIES L-9

Automation – Definition, levels, need, strategies principles. Types of production, functions in manufacturing, plant layout – types, organization and information processing in manufacturing, Types of flow lines, methods of transport, transfer mechanisms, ASRS system.

UNIT II GROUP TECHNOLOGY & FLEXIBLE MANUFACTURING SYSTEMS L-9

Group Technology – Introduction, part families, parts classification and coding system – OPITZ and MI CLASS system. Production flow analysis, cellular manufacturing – advantages, disadvantages and applications. FMS – Introduction, workstations, scope, components, types,

benefits, typical FMS layout configuration, function of FMS computer Control System, FMS data files.

UNIT III COMPUTER CONTROL SYSTEMS & AUTOMATED PROCESS L-9

Computer control systems – Introduction, Architecture, Factory Communication, Local Area Networks – Characteristics, factory networks, open system interconnection model. Network to network interconnections, manufacturing automation protocol, Data Base Management System – Introduction. Computer aided shop floor control. Automated process planning – introduction, structure, information requirement, CAPP, application, programs in CAPP.

UNIT IV COMPUTER CONTROLLED MACHINES & MATERIAL HANDLING L-9 **SYSTEMS**

NC machines – Part Programming, CNC, DNC, Adaptive Control, Pallets & Fixtures, Machine centers, Automated inspection systems. Material handling systems – Introduction, Conveyors, Industrial Robots, Automated Guided Vehicles.

UNIT V COMPUTER INTEGRATED MANUFACTURING L-9

CIM – Introduction, definition, scope, benefits, elements, CIM cycle or wheel. Introduction to Just-in-Time (JIT), Kanban System, Business Process Re-engineering (BPR), Materials requirement planning (MRP), Manufacturing Resource Planning (MRP II), Enterprise Resource Planning (ERP), Supply Chain Management (SCM).

TOTAL: 45 PERIODS

8. Text Books

1. Mikell Groover .P, Automation, Production Systems and Computer Integrated Manufacturing”, Prentice Hall of India Pvt. Ltd., 2001.
2. Viswanathan .N, Navahari .Y “Performance Modeling of Automated Manufacturing Systems”, Prentice Hall of India Pvt. Ltd., 1998.

9. References

1. Rao .P.N., *Computer Aided Manufacturing*, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 2001.
2. Kant Vajpayee .S, *Principles of Computer Integrated Manufacturing*, Prentice Hall of India Pvt. Ltd., 1995.
3. Radhakrishnan .P, Subramaniyan .S, *CAD/CAM/CIM*, New Age International Limited, 1994.

COURSE CODE	FLEXIBLE MANUFACTURING SYSTEMS	L	T	P	C
10212ME158		3	0	0	3

1. Preamble

This course provide concept of various production system, group technology, Flexible manufacturing system and FMS software.

2. Pre-requisite

NIL

3. Link to the other courses

Factory automation

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the concept of various production systems and group technology
- Understand the concept of Flexible manufacturing and FMS software.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Discuss the types, layout and functions of production systems	K2
CO2	Explain the classifications of part families, coding methods and benefits of group technology	K2
CO3	Explain the need, applications, benefits and limitations of flexible manufacturing systems	K2
CO4	Describe the classifications, component handling and hardware configurations of flexible manufacturing systems	K2
CO5	Explain the requirements and functions of FMS software and testing procedure for performance improvement.	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	M											H	
CO2	L	M											H	
CO3	L	M											H	
CO4	L	M											H	
CO5	L	M	L		M							M	H	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I PRODUCTION SYSTEMS

L-9

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

UNIT II GROUP TECHNOLOGY

L-9

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

UNIT III FLEXIBLE MANUFACTURING SYSTEMS**L-9**

Introduction – Evolution – Definition - Need for FMS - Need for Flexibility - Economic Justification of FMS-Application Criteria - Machine tool Selection and Layout - Computer control system - Data files – Reports - Planning the FMS - Analysis Methods for FMS - Benefits and limitations.

UNIT IV FLEXIBLE MANUFACTURING CELLS**L-9**

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

UNIT V FMS SOFTWARE**L-9**

Introduction - General Structure and requirements - Functional descriptions - Operational overview - Computer simulation - FMS installation – Objective - Acceptance testing - Performance goals – Expectations - Continued support.

TOTAL: 45 PERIODS**8. Text Books**

1. William W.Luggen., Flexible Manufacturing Cells and Systems, Prentice Hall, NJ, 1991.
2. Mikell P.Groover., Automation Production Systems &Computer Integrated manufacturing, PHI, 1989.

9. References

1. David J.Parrish., *Flexible Manufacturing*, Butterworth-Heinemann, 1990.
2. Buffa, E.S., *Modern Production and Operation Management*, 1985.
3. Jha N.K., Handbook of Flexible manufacturing system, Academic press Inc, 1991.

COURSE CODE	INTELLIGENT MANUFACTURING TECHNOLOGY	L	T	P	C
10212ME159		3	0	0	3

- This course provide the concept of various sensors in manufacturing, principles of monitoring systems, and automatic identification techniques in intelligent manufacturing technology.
- Pre-requisite**
10212ME154 -Industrial Robotics
- Link to the other courses**
Factory automation
- Course Educational Objectives**
Students, after undergoing this course would
 - Understand the concept of manufacturing automation and principles of various sensors.
 - Understand the concept of automatic monitoring and identification techniques.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Discuss the types, working and applications of sensors used in manufacturing automation.	K2
CO2	Illustrate the working and selection of sensor used in robotic and CNC machine tools application.	K3
CO3	Illustrate the online and offline process monitoring and fault monitoring systems.	K3
CO4	Describe the selection process of sensors for force, vibration and noise applications	K2
CO5	Discuss the automatic identification techniques in manufacturing automation process	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	M											M	
CO2	L	H	L					L					M	L
CO3	L	H	L					L					M	L
CO4	L	M											M	
CO5	L	M											M	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION

L-9

Introduction – Role of sensors in manufacturing automation- operation principles of different sensors –electrical, optical, acoustic, pneumatic, magnetic, electro-optical, photo – electric, vision, proximity, tactile, range sensors.

UNIT II SENSORS IN MANUFACTURING

L-9

Sensors in manufacturing – Temperature sensors in process control-Pressure sensors – Fiber optic sensors and their principles and applications – Displacement sensor for robotic

application- Sensors for CNC machine tools – Linear and angular position sensors, velocity sensors. Sensors in Robotics – encoder, resolver, potentiometers, range, proximity, touch sensors.

UNIT III PROCESS MONITORING

L-9

Principle, Sensors for Process Monitoring - online and off line quality control, Quality parameter design Direct monitoring of fault based on process signals.

UNIT IV CONDITION MONITORING

L-9

Condition monitoring of manufacturing systems -principles –sensors for monitoring force, vibration and noise. Selection of sensors and monitoring techniques. Acoustics emission sensors-principles and applications-online tool wear monitoring.

UNIT V AUTOMATIC IDENTIFICATION TECHNIQUES

L-9

MRP -MRPII-Shop floor control –Factory data collection systems – Automatic identification methods – Bar code technology, automated data collection system – Agile manufacturing-flexible manufacturing-Enterprise integration and factory information system.

TOTAL: 45 PERIODS

8. Text Books

1. Sabrie salomon, Sensors and Control Systems in Manufacturing, McGraw Hill int. edition, 1994.
2. Patranabis .D, Sensors and Transducers, Wheeler publishers, 1994.
3. S.R.Deb, Robotics technology and flexible automation, Tata McGraw Hill publishing Co. Ltd., 1994.

9. References

1. Mikell P. Groover, *Automation Production System and Computer Integrated Manufacturing*, Prentice Hall of India Ltd., 2001.
2. Richard D.Klafter, *Robotic Engineering*, Prentice Hall of India Pvt., Ltd., 2001.
3. Julian W.Gardner, *Micro Sensor MEMS and Smart Devices*, John Wiley & Sons, 2001.
4. Randy Frank, *Understanding Smart Sensors*, Artech house, USA, 1996.

Open Elective

COURSE CODE	COMPOSITES AND POLYMERS	L	T	P	C
10213ME101		3	0	0	3

1. Preamble

The course provides an introduction to the need, properties, application, and manufacturing processes of various composite materials.

2. Pre-requisite

Engineering Materials and Metallurgy

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- To understand the characteristics of different reinforcement matrix materials.
- Know the, properties and application of different types of reinforcements and matrices.
- Understand the fabrication techniques involved in the polymer, metal, and ceramic matrix composites.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describes various types of composite materials and their applications.	K2
CO2	Describe various manufacturing processes of Polymer Matrix Composite	K2
CO3	Apply the principles of mechanics for Metal Matrix Composites	K3
CO4	Explain the need of Ceramic Matrix Composites and their practical applications	K2
CO5	Describe the advances in composite materials	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	L	L									
CO2	H	L	L									
CO3	H	L	L									
CO4	H	L	L									
CO5	H	L	L									

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION

L-9

Fundamentals of composites, Classification of polymers – properties and applications of selective engineering polymers – fundamentals of composites – need for composites – enhancement of properties – classification of composites – matrix polymer matrix composites (PMC), metal matrix composites (MMC), Ceramic matrix composites (CMC) reinforcement – particle reinforced composites, fibre reinforced composites, applications of various types of composites.

UNIT II POLYMER MATRIX COMPOSITES

L-9

Polymer matrix resins – thermosetting resins, thermoplastic resins – reinforcement fibres – rovings – woven fabrics – non woven random mats – various types of fibres, Processing of polymer matrix composites- hand lay-up, Spray lay-up processes, Compression molding- SMC Reinforced reaction injection molding, Resin transfer molding, Pultrusion, Filament winding, Applications of polymer matrix composites.

UNIT III METAL MATRIX COMPOSITES

L-9

Characteristics of MMCs, Various types of Metal matrix composites, Advantages and limitations of MMCs, Effect of reinforcements on properties – Volume fraction – Rule of mixtures, Processing of MMCs - Liquid state processing- stir casting, squeeze casting, infiltration, solid state processing - Powder metallurgy, diffusion bonding, In situ processes, applications of MMCs.

UNIT IV CERAMIC MATRIX COMPOSITES

L-9

Need for CMCs, Processing of CMCs- cold pressing and sintering, hot pressing, infiltration, chemical vapor deposition and chemical vapor impregnation, sol-gel and polymer pyrolysis, high temperature synthesis properties and applications of CMC.

UNIT V ADVANCES IN COMPOSITES

L-9

Carbon fiber composites – properties, chemical vapor deposition– oxidative etching, liquid phase oxidation carbon/carbon composites - properties and applications of C/C Composites, multifilament superconducting composites.

TOTAL: 45 PERIODS

8. Text Books

1. Ronald Gibson, Principles of Composite Material Mechanics, Tata McGraw Hill, 2013.
2. P.K.Mallicak, Fiber-reinforced composites, Monal Deklar Inc., New York, 2013.

9. References

1. F.L.Matthews & R.D.Rawlings, Composite Materials, Engg and Sci, Chapman & hall, London, 2001.
2. Micael hyer, Stress Analysis of Fiber - Reinforced Composite Materials, Tata McGraw Hill, 2006.
3. Ronald Gibson, Principles of Composite Material Mechanics, Tata McGraw Hill, 2001.
4. Sanjay.K.Majumdar, Composites Manufacturing, Kindle edition, CRC press, 2001.

COURSE CODE	INTEGRATED PRODUCT DEVELOPMENT	L	T	P	C
10213ME102		3	0	0	3

1. Preamble

This course is designed to provide the knowledge about the concepts of various tools and Approaches available for product development.

2. Pre-requisite

NIL

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the concepts of tools and techniques in the Integrated Product Development area of the Engineering Services industry.
- Relate the engineering topics into real world engineering applications.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Summarize the various trends affecting product decision.	K2
CO2	Identify the requirements to create new product.	K3
CO3	Compare different techniques involved in design creation and design testing.	K2
CO4	Rephrase the methods of model creation and integration between software and hardware.	K2
CO5	Illustrate the need of end of life and patenting.	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	L				L	L	L	L			L
CO2	H	L				L	L	L	L			L
CO3	H	L				L	L	L	L			L
CO4	H	L				L	L	L	L			L
CO5	H	L				L	L	L	L			L

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I FUNDAMENTALS OF PRODUCT DEVELOPMENT L-9

Global Trends Analysis and Product decision: Types of various trends affecting product decision - Social Trends-Technical Trends- Economic Trends- Environmental Trends- Political/ Policy Trends- PESTLE Analysis. Introduction to Product Development Methodologies and Management: Overview of Products and Services- Types of Product Development- Overview of Product Development methodologies - Product Life Cycle - Product Development Planning and Management.

UNIT II REQUIREMENTS AND SYSTEM DESIGN L-9

Requirement Engineering: Types of Requirements- Requirement Engineering-Analysis -Traceability Matrix and Analysis- Requirement Management. System Design & Modeling: Introduction to System Modeling- introduction to System Optimization- System Specification-Sub-System Design- Interface Design.

UNIT III DESIGN AND TESTING L-9

Conceptualization -Industrial Design and User Interface Design- Introduction to Concept generation Techniques-Concept Screening & Evaluation- Concept Design- S/W Architecture- Hardware Schematics and simulation-Detailed Design: Component Design and Verification- High Level Design/Low Level Design of S/W Programs- S/W Testing-Hardware Schematic- Component design- Layout and Hardware Testing.

UNIT IV IMPLEMENTATION & INTEGRATION L-9

Prototyping: Types of Prototypes -Introduction to Rapid Prototyping and Rapid Manufacturing. System Integration- Testing- Certification and Documentation: Introduction to Manufacturing /Purchase and Assembly of Systems- Integration of Mechanical, Embedded and S/W systems- Introduction to Product verification and validation processes - Product Testing standards, Certification and Documentation.

UNIT V SUSTENANCE ENGINEERING AND BUSINESS DYNAMICS L-9

Sustenance -Maintenance and Repair- Enhancements Product End of Life (EoL):
Obsolescence Management-Configuration Management- EoL Disposal.

The Industry - Engineering Services Industry overview- Product development in Industry versus Academia The IPD Essentials- Introduction to vertical specific product development processes- Product development Trade-offs- Intellectual Property Rights and Confidentiality- Security and configuration management.

TOTAL: 45 PERIODS

8. Text Books

1. NASSCOM student Handbook "Foundation Skills in Integrated Product Development".
2. Anita Goyal, Karl T Ulrich, Steven D Eppinger, "Product Design and Development ", 4th Edition, 2009, Tata McGraw-Hill Education, ISBN-10-007-14679-9.

9. References

1. 1. George E.Dieter, Linda C.Schmidt, "Engineering Design", McGraw-Hill International Edition, 4th Edition, 2009, ISBN 978-007-127189-9
2. 2. Kevin Otto, Kristin Wood, "Product Design", Indian Reprint 2004, Pearson Education, ISBN. 9788177588217
3. 3. Yousef Haik, T. M. M. Shahin, "Engineering Design Process", 2nd Edition Reprint, Cengage Learning, 2010, ISBN 0495668141
4. 4. Clive L.Dym, Patrick Little, "Engineering Design: A Project-based Introduction", 3rd Edition, John Wiley & Sons, 2009, ISBN 978-0-470-22596-7
5. 5. Product Design Techniques in Reverse Engineering and New Product Development, KEVIN OTTO & KRISTIN WOOD, Pearson Education (LPE), 2001.
6. 6. The Management and control of Quality-6th edition-James R. Evens, William M Lindsay Pub:son south-western(www.swlearning.com).

COURSE CODE	PRODUCT DESIGN AND ENTREPRENEURSHIP	L	T	P	C
10213ME103		3	0	0	3

1. Preamble

The course is designed to provide the basic concepts of product design, product features and its architecture so that student can have a basic knowledge in the common features a product has and how to incorporate them suitably in product. The course also aim to provide an understanding of the scope of an entrepreneur, key areas of development, financial assistance by the institutions, methods of taxation and tax benefits, etc.

2. Pre-requisite

NIL

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the basic concepts of product design, product features and its architecture.
- Understand the scope of an entrepreneur, financial assistance by the institutions, taxations and tax benefit.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Understand the integration of customer requirements in product design	K2
CO2	Apply structural approach to concept generation, selection and testing	K3
CO3	Understand various aspects of design such as industrial design, design for manufacture, economic analysis and product architecture	K2
CO4	Understand the various aspects of innovation and methods of fostering Innovation	K2
CO5	Apply knowledge and skills needed to run a business	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	M	L			L	L				L	L
CO2	H	M	L			L	L				L	L
CO3	H	M	L			L	L				L	L
CO4	H	M	L			L	L		L		L	L
CO5	H	M	L			L	L		L		L	L

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION TO PRODUCT DEVELOPMENT L-9

Characteristic of successful product development-Strategic importance and challenges of Product development-Product development process flows-Competitor and customer-behavior analysis. Understanding customer-promoting customer understanding-involve customer in development and managing requirements- Organization process management and improvement.

UNIT II CONCEPT GENERATION, SELECTION AND TESTING L-9

Plan and establish product specifications. Task-Structured approaches -clarification-search- externally and internally-Explore systematically-reflect on the solutions and processes-concept selection-methodology-benefits. Implications-Product change-variety -component standardization- product performance - manufacturability – Concept Testing Methodologies.

UNIT III INDUSTRIAL DESIGN L-9

Need for industrial design-Impact of industrial design– Process of industrial design-Simulating product performance and manufacturing processes electronically-investigation of customer needs-conceptualization-refinement - management of the industrial design process –technology driven products - user- driven products - assessing the quality of industrial design.

UNIT IV ENTREPRENEURSHIP AND ENTREPRENEURIAL MOTIVATION L-9

Definition, Requirements to be an entrepreneur, Entrepreneur and Manager, Growth of entrepreneurship in India, Women Entrepreneurship, Rural and Urban Entrepreneurship. Motivating factors, Motivation Theories-Maslow's Need Hierarchy Theory, McClelland's Acquired Need Theory, Government's Policy actions towards Entrepreneurial motivation, Entrepreneurship development Programs.

UNIT V PROJECTS, TYPES OF ENTERPRISES AND OWNERSHIP STRUCTURE L-9

Understanding and Representing tasks-Gantt charts-Pert charts, Identification and selection of projects; project report: contents and formulation, concept of project evaluation, methods of project evaluation: internal rate of return method and net present value method. Small scale, medium scale and large scale enterprises, role of small enterprises in economic development; proprietorship, partnership, Ltd. companies and co-operatives: their formation, capital structure and source of finance.

TOTAL: 45 PERIODS

8. Text Books

1. Product Design and Development, Karl T.Ulrich and Steven D.Eppinger, McGraw –Hill International Edns.1999
2. S.S.Khanka "Entrepreneurial Development" S.Chand & Co. Ltd. Ram Nagar New Delhi, 1999.

9. References

1. Effective Product Design and Development, Stephen Rosenthal, Business

One Orwin,

2. Homewood, 1992,ISBN, 1-55623-603-4
3. Tool Design – Integrated Methods for successful Product Engineering, Stuart Pugh, Addison
4. Wesley Publishing, New York, NY, 1991, ISBN 0-202-41639-5
5. Hisrich R D and Peters M P, “Entrepreneurship” 5th Edition Tata McGraw-Hill, 2002.

COURSE CODE	INTELLECTUAL PROPERTY RIGHTS FOR	L	T	P	C
10213ME104	ENGINEERS	3	0	0	3

1. Preamble

The course is designed 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. Pre-requisite

NIL

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the concepts of all aspects of the IPR Acts.
- Relate the application of the legal concepts in Science, Engineering, Technology and Creative Design.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Understand the fundamentals of intellectual property rights, as well as be exposed to current developments on a national and international level.	K2
CO2	Apply the ideas of creating and defending inventions, as well as filing patent applications.	K3
CO3	Correlate the concepts of copyrights to exposure to licensing and copyright transfer.	K2
CO4	Recognize the significance of trademarks, industrial design, and geographic indications.	K2
CO5	Appreciate the relevance of unfair competition in IPR, as well as case studies in geographical indications and their challenges.	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

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

(H- High; M-Medium; L-Low)

7. Course Content**UNIT I INTRODUCTION TO IPR****L-9**

Introduction – Invention and Creativity – Intellectual Property (IP) – Importance – IPR in India and IPR abroad Protection of IPR – Basic types of property - Movable Property - Immovable Property - Intellectual Property. Kinds of Intellectual Property Rights: Patent, Copyright, Trade Mark, Design, Geographical Indication, Plant Varieties and Layout Design- Genetic Resources and Traditional Knowledge. Paris Convention, Berne Convention, WIPO Convention, Patent Cooperation Treaty and TRIPS agreement.

UNIT II PATENTS**L-9**

Patents - their definition –elements- granting - infringement - searching & filing - Utility Models an introduction. Patentability of Biotechnology Inventions, software and Computer related Inventions.

UNIT III COPYRIGHTS**L-9**

Copyrights - their definition - granting - infringement - searching & filing - distinction between related and copy rights. Academic integrity or Plagiarism: An Intellectual theft. Protecting Copyright in Social Media .Copyright issues in digital Environment.

UNIT IV TRADEMARKS AND GEOGRAPHICAL INDICATIONS**L-9**

Trademarks - role in commerce -importance – protection- registration - domain names - Industrial Designs - Design Patents – scope – protection - filing infringement - difference between Designs & Patents - Geographical indications - International Protection.

UNIT V CASE STUDIES IN IPR**L-9**

Case Studies on – Patents (Basmati rice, Turmeric, Neem, etc.) – Copyright and related rights – Trade Marks – Industrial design and Integrated circuits – Geographic indications – Protection against unfair competition –Biotechnology Patents-Computer related Inventions.

TOTAL: 45 PERIODS

8. Text Books

1. Nithyananda, K V. (2019). Intellectual Property Rights: Protection and Management. India, IN:Cengage Learning India Private Limited.
2. R. Radha Krishnan, S. Balasubramanian: "Intellectual Property Rights", Excel Books. New Delhi.

9. References

1. Neeraj, P., & Khusdeep, D. (2014). Intellectual Property Rights. India, IN: PHI learning Private Limited.
2. Eli Whitney, United States Patent Number: 72X, Cotton Gin, March 14, 1794.
3. Subbaram N.R. "Handbook of Indian Patent Law and Practice ", S. Viswanathan Printers and Publishers Pvt. Ltd., 1998
4. Intellectual Property Today: Volume 8, No. 5, May 2001, [www.iptoday.com].
5. Using the Internet for non-patent prior art searches, Derwent IP Matters, July 2000.
Web Resources www.ipmatters.net/features/000707_gibbs.html.

COURSE CODE	3D PRINTING AND TOOLING	L	T	P	C
10213ME105		3	0	0	3

1. Preamble

This course addresses additive manufacturing principles, variety and its concept, scope of additive manufacturing and areas of application.

2. Pre-requisite

NIL

3. Link to the other courses

Project work

4. Course Educational Objectives

Students, after undergoing this course would

- Know the principles, methods, areas of usage, possibilities and limitations as well as environmental effects of the additive manufacturing technologies
- Be familiar with the characteristics of various materials that are used in additive manufacturing.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describe the differences and of the application of a range of additive manufacturing processes.	K2
CO2	Select and use correct CAD formats in the manufacture of a 3D printed part.	K2
CO3	Understand the operating principles, capabilities, and limitations of liquid and solid based additive manufacturing system, including fused deposition modeling and stereolithography.	K2
CO4	Appreciate the operating principles, capabilities and limitations of powder based additive manufacturing system, including 3D printing and laser sintering.	K2
CO5	Describe the important process parameters for bio-manufacturing and determine the suitable additive technique for bio-manufacturing.	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

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

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION

L-9

Overview - History - Classification – Fundamental Wheel - Additive manufacturing Technology in product development – Process Chain - Materials for Additive Manufacturing.

UNIT II CAD & REVERSE ENGINEERING

L-9

Basic Concept –3D scanning- Digitization techniques – Model Reconstruction – Data Processing for Reverse Engineering- Additive Manufacturing Technology: CAD model preparation – Part Orientation and support generation – Model Slicing –Tool path Generation.

UNIT III LIQUID BASED AND SOLID BASED ADDITIVE MANUFACTURING SYSTEMS

L-9

Introduction – Classification of Additive Manufacturing system – Liquid based system – Stereo lithography Apparatus (SLA) - principle, process, advantages, disadvantages and applications – Solid based system –Fused Deposition Modeling (FDM) – principle, process, advantages, disadvantages and applications.

UNIT IV POWDER BASED ADDITIVE MANUFACTURING SYSTEMS

L-9

Introduction - Selective Laser Sintering (SLS), – principle, process, advantages, disadvantages and applications - Three Dimensional Printing (3DP) – principle, process, advantages, disadvantages and applications - Laser Engineered Net Shaping (LENS)- principle, process, advantages, disadvantages and applications.

UNIT V RAPID TOOLING AND APPLICATIONS OF ADDITIVE MANUFACTURING

L-9

Introduction – Classification - Soft tooling, Production tooling, Bridge tooling, direct and indirect tooling, Fabrication Process - Applications of Additive manufacturing in Aerospace, Automotive, Manufacturing, Biomedical and Jewelry Industry.

TOTAL: 45 PERIODS

8. Text Books

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

9. References

1. Liou L.W. and Liou F.W., “Rapid Prototyping and Engineering applications: A tool box for prototype development”, CRC Press, 2007.
2. Kamrani A.K. and Nasr E.A., “Rapid Prototyping: Theory and practice”, Springer, 2006.
3. Hilton P.D. and Jacobs P.F., “Rapid Tooling: Technologies and Industrial Applications”, CRC press, 2000.
4. Douglas Bryden, “CAD and Prototyping for Product Design”, 2014.

COURSE CODE	MEMS AND NANO TECHNOLOGY	L	T	P	C
10213ME106		3	0	0	3

1. Preamble

This course provides insight into the fundamental and basic principles of micro electro mechanical systems (MEMS) and Nanotechnology.

2. Pre-requisite

Engineering Materials and Metallurgy.

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- To understand the fundamentals of micro electro mechanical systems (MEMS) and fabrication of MEMS devices.
- To understand the fundamentals of nanomaterial, different classes and its characterization.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Know the scaling laws that are used extensively in the conceptual design of micro-device and able to use materials for common micro components and devices	K2
CO2	Select a fabrication process suitable for production of a MEMs device	K2
CO3	Explain the principle analysis of one-dimensional nanomaterials.	K2
CO4	Describe the super hard coatings and nano structured materials.	K2
CO5	To study the characterization of nanomaterials.	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H				L		L					
CO2	H				L		L					
CO3	H				L		L					
CO4	H				L		L					
CO5	H				L		L					

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION TO MEMS L-9

Definition, Introduction to Microsystems and microelectronics, evolution of MEMS, Market scenario for MEMS, Materials for MEMS: Silicon as a MEMS material, polymers for MEMS, multi-disciplinary nature of MEMS. Some present and future applications of MEMS.

UNIT II MICROSYSTEM FABRICATION PROCESS L-9

Clean room technology - Substrates and wafer, Photolithography, Ion Implantation, Diffusion, Oxidation: (Thermal oxidation), Chemical Vapour Deposition, Physical Vapour Deposition: (Sputtering), Etching, Micromaching: Bulk Micromachining – Surface Micromachining.

UNIT III INTRODUCTION TO NANOMATERIALS L-9

History of Nanomaterials, Definition, Feynman predictions on Nanotechnology, Role of Bottom up and top down approaches in nanotechnology, challenges in Nanotechnology, Some present and future applications of nanomaterials.

UNIT IV DIFFERENT CLASSES OF NANOMATERIALS L-9

Classification based on dimensionality-Quantum Dots, Wells and Wires- Carbon-based nano materials (buckyballs, nanotubes, graphene)-Metalbased nano materials (nanogold, nanosilver and metal oxides) -Nanocomposites- Nanopolymers - Nanoglasses -Nano ceramics -Biological nanomaterials.

UNIT V CHARACTERIZATION TECHNIQUES L-9

Scanning Electron Microscope (SEM), Energy Dispersive Analysis of X-rays (EDAX), Transmission Electron Microscope (TEM), Atomic Force Microscope (AFM), Scanning Tunnelling Microscope (STM), Electrostatic Force Mode (EFM), Magnetic Force Mode (MFM) - Nano indentation.

TOTAL: 45 PERIODS

8. Text Books

1. Tai Ran Hsu, MEMS and Micro Systems Design and Manufacture, Tata McGraw-Hill Publishing Company Ltd, New Delhi, 2008
2. Nadim Maluf, An Introduction to Micro Electro Mechanical System Design, Artech House Publishers, London, 2004
3. Carl C. Koch (ed.), "Nanostructured Materials", Processing, Properties and Potential Applications, Noyes Publications, Norwich, New York, U.S.A.
4. HariSinghNalwa, "NanostructuredMaterialsandNanotechnology", Academic Press, First Edition 2002

9. References

1. Chang Liu, Foundations of MEMS, Pearson Education, New Delhi, 2011. James J. Allen, Micro Electro Mechanical System Design, CRC Press Publishers, India, 2005
2. Julian w. Gardner, Vijay K. Varadan and Osama O. Awadelkarim, Micro sensors MEMS and smart Devices, John Wiley and Sons Ltd., England, 2002

3. Mark Ratner and Daniel Ratner, "Nano Technology", Pearson Education, New Delhi, 2003.
4. Charles P. Poole Jr., Frank J. Ownes, 'Introduction to Nanotechnology", Wiley Interscience, 2003.

COURSE CODE	INDUSTRIAL NANOTECHNOLOGY	L	T	P	C
10213ME107		3	0	0	3

1. Preamble

To provide knowledge of various industrial applications of nanotechnology.

2. Pre-requisite

NIL

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Elucidate on advantages of nanotechnology-based applications in each industry.
- Provide instances of contemporary industrial applications of nanotechnology.
- Provide an overview of future technological advancements and increasing role of nanotechnology in each industry.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	The application of Nanotechnology in Electrical and Electronics Industry	K2
CO2	The application of Nanotechnology in Textiles and Cosmetics	K2
CO3	The application of Nanotechnology in Agriculture and Food Technology	K2
CO4	The application of Nanotechnology in Renewable and Nonrenewable Energy Technology	K2
CO5	The application of Nanotechnology in Environmental and Health Effects	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

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

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I NANOTECHNOLOGY IN ELECTRICAL AND ELECTRONICS L-9 INDUSTRY

Advantages of nano electrical and electronic devices – Data storage and memory- Micro and nanoelectromechanical systems - Lighting and displays – Batteries- Fuel cells- Photovoltaic cells- Electric double layer capacitors- Nanoparticle coatings for electrical products.

UNIT II NANOTECHNOLOGY IN TEXTILES AND COSMETICS L-9

Textiles: Nanofibre production - Electrospinning - Controlling morphologies of nanofibers- Nano -fillers embedded polypropylene fibers - Bionics - Swim-suits with shark-skin effect, Soil repellence, Lotus effect - Nano finishing in textiles. Cosmetics: Formulation of Gels, Shampoos, Hair-conditioners (Micellar self-assembly and its manipulation) - Sun-screen dispersions for UV protection using titanium oxide - Colour cosmetics.

UNIT III NANOTECHNOLOGY IN AGRICULTURE AND FOOD L-9 TECHNOLOGY

Nanotechnology in Agriculture - Precision farming, Smart delivery system - Nano fertilizers: Nanourea and mixed fertilizers, Nanotechnology in Food industry -Nano packaging for enhanced shelf life -Smart/Intelligent packaging - Food processing and food safety and bio-security - Electrochemical sensors for food analysis and contaminant detection.

UNIT IV NANOTECHNOLOGY IN RENEWABLE AND L-9 NONRENEWABLE ENERGY TECHNOLOGY

Energy Challenge in the 21st Century- Nanotechnology in energy research- Conventional fossil fuels- Unconventional fossil fuels- Nanotechnology in fuel production- Renewable energy sources photovoltaics -Hydrogen production - fuel cells- thermoelectricity- Advantages of renewable energy technologies.

UNIT V NANOTECHNOLOGY IN ENVIRONMENTAL AND HEALTH L-9 EFFECTS

Environmental pollutants in air, water, soil, hazardous and toxic wastes - Application of Nanotechnology in remediation of pollution in Industrial and waste water treatment – Drinking water and Air/Gas purifications. The challenge to occupational health and hygiene, toxicity of nanoparticles, effects of inhaled nanosized particles, skin exposure to nanoparticles.

TOTAL: 45 PERIODS

8. Text Books

1. P.Brown and K. Stevens, Nanofibers and Nanotechnology in Textiles, Wood head publication,London, 2006.
2. J.Altmann, Routledge, Military Nanotechnology: Potential Applications and Preventive Arms Control, Taylor and Francis Group, 2006.
3. Jennifer Kuzma and Peter VerHage, Nanotechnology in agriculture and food production, Woodrow Wilson International Center, (2006).
4. Q. Chaudry, L.Castle and R. Watkins Nanotechnologies in Food, RSC Publications, 2010.

9. References

1. Y-W. Mai,Polymer Nano composites, Woodhead publishing, (2006).
2. Udo H. Brinker, Jean-Luc Mieusset (Eds.), Molecular Encapsulation: Organic Reactions in Constrained Systems,Wiley Publishers (2010).

COURSE CODE	INDUSTRY 4.0	L	T	P	C
10213ME108		3	0	0	3

1. Preamble

Industry 4.0 concerns the transformation of industrial processes through the integration of modern technologies such as sensors, communication, and computational processing Technologies such as Cyber Physical Systems, Internet of Things, Cloud Computing, Machine Learning, and Data Analytics are accelerating the digital transformation Industry 4.0 makes the manufacturing to be agile and makes production planning more efficient through advanced performance management of the plant asset and reduces plant down time for maintenance etc.

2. Pre-requisite

NIL

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the basics and the evolution of Industry 4.0.
- Understand the smart manufacturing concepts Cyber Physical Systems, Internet of Things, Cloud Computing, Machine Learning, and Data Analytics.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Explain the need and basics of Industry 4.0	K2
CO2	Explain about IIOT concepts.	K2
CO3	Illustrate about the smart manufacturing systems.	K2
CO4	Describe about the trends in Big Data	K2
CO5	Describe about the application of smart manufacturing	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	L	L			L							L
CO2	L	L			L							L
CO3	L	L			L							L
CO4	L	L			L							L
CO5	L	L			L							L

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION

L-9

Introduction-Industry 4.0, Global Roadmap and initiatives, Sustainability assessment of Manufacturing industry, Cyber physical system and security.

UNIT II IIOT AND ANALYTICS

L-9

AR & VR in Manufacturing, Big data and Analytics in Manufacturing, Basics of IIOT, Industrial Sensing and Actuation system.

UNIT III SMART CONNECTED FACTORY

L-9

Digital connected factory, Additive manufacturing, Factory connected with logistics 4.0, warehouse 4.0, Asset Monitoring and predictive analytics.

UNIT IV BIG DATA CONCEPTS

L-9

IT/OT integration, Manufacturing operation management, M2M Communication, Analytics and data management, Plant security and safety.

UNIT V SMART FACTORY APPLICATION

L-9

Business model and Reference Architecture, Cloud Computing and cloud based design and manufacturing, Automotive, Medical, Consumer goods /Telecommunication, FMCG.

TOTAL: 45 PERIODS

8. Text Books

1. Industry 4.0: The Industrial Internet of Things”, by Alasdair Gilchrist (Apress)
2. “Industrial Internet of Things: Cyber manufacturing Systems “by Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat (Springer)

9. References

1. Introduction to Industry 4.0 and Industrial Internet of Things by Prof.SudipMisra,IIT Kharagpur. Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]
2. A. McEwen and H. Cassimally, Designing the Internet of Things, 1st edition, Wiley, 2013, ISBN-10: 111843062X.
3. N. Vengurlekar and P. Bagal, Database Cloud Storage: The Essential Guide to Oracle Automatic Storage Management, 1st edition, McGraw-Hill Education, 2013, ISBN-10: 0071790152.

COURSE CODE	MATLAB PROGRAMING FOR ENGINEERS	L	T	P	C
10213ME201		2	0	2	3

1. Preamble

2. Pre-requisite

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Program for engineering problem solving using the MATLAB software package
- Develop the skills to analyze and break down an engineering program and solve it algorithmically using MATLAB

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Understand the basic mathematical functions in MATLAB to solve the simple and basic problems	K3
CO2	Use matrix mathematical functions to solve the simple problems	K3
CO3	Use the logical operator and relational operator to solve the simple problems	K3
CO4	Develop programs using MATLAB	K3
CO5	Import and export the data/information	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	H	H								
CO2	H	H	H	H								
CO3	H	H	H	H								
CO4	H	H	H	H								
CO5	H	H	H	H								

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION AND BASICS

L-6

Introduction to MATLAB-Environment: Desktop, Tool Strips, Font, Color, Search Function, Code Suggestion – Basics: Using MATLAB as a calculator, Data types, Arithmetic Operator, Hierarchy, Creating Variables, Input & Output, Formats, Managing workspace, tracking record, Getting Help.

UNIT II HANDLING OF MATRIX AND MATHEMATICAL FUNCTIONS

L-6

Handling of Matrix: Matrix Definition, Retrieving data, Add/delete/Transpose, Arithmetic operation, Element wise operation – Mathematical functions: Elementary Function, Specialized Function and Other Functions.

UNIT III LOGICAL & RELATIONAL OPERATORS AND FLOW CONTROL

L-6

Logical operator - relational operator – Conditional control statements: if, else if, nested if statements, switch statement – Loop control: for, while, break and continue statements – Error control: try, catch.

UNIT IV BASICS IN PROGRAMMING

L-6

Working with M files, Scripts and functions, types of functions, function argument, function handling, calling function, live script, error handling, improving performance and memory usage.

UNIT V DATA IMPORT & EXPORT AND VISUALIZING DATA

L-6

Import and export: text data – spread sheet - audio and video data and workspace data – visualizing data: creating simple plot – adding title, axis labels and annotations – multiple data set in single plot – specifying line style and color – different types of plot – handles and attributes.

Problems for Solving in Laboratory

Note:

1. Program design and development shall be done off-laboratory
2. The students shall come to the laboratory with code and test cases.
3. The laboratory time shall be used for testing the program

UNIT I

- i) Create a variable named as dis and assign last three digits of your unique id as its value.
- ii) Create a row vector with last four digits of your unique id as elements and assign a name RV.
- iii) Create a 2 by 3 matrix using last six digits of your unique id. Assign m1 as variable name.

- iv) Using your unique id calculate the value of the following expression. The number indicates the position of the digit in your unique id. Display the answer with more than six digits accuracy.

$$245*(13^{24}+567-17)/135$$

- v) Using input function get your age as third and seventh digit of your unique id and store it in the variable name Age
vi) Using input function get your name and store it in variable Name.
vii) Display your name in the screen using appropriate function.
viii) Display the list of variables created so far with its type.

P-10

UNIT II

- i) Add 6 and 7 as last two digits with your unique id. Construct a 3 by 3 matrix and assign a name m1.
ii) Retrieve entire elements of 2nd row of m1.
iii) Display the output of m1(2,2:3)
iv) Display the output of m1([1 3],1:3)
v) Display the output of [m1 m1(:,3)]
vi) Assign m3 as sum of 3rd column of m1 and 2nd column of m1 and display the answer.
vii) Do elementwise multiplication between 1st and 3rd row of m1 and assign the answer as m4
viii) Perform elementwise multiplication between 2nd row of m1 and 1st column of m1. Assign m5 for the result.
ix) Delete 2nd column of m1 and assign the result as m2.
x) Assign a1 as your unique id with placing decimal point before last digit. Display the answer of ceil(a1) and floor(-a1)
xi) Generate m by n random numbers between 0 and 1 by assuming m as first digit and n as last digit of your unique id.
xii) Generate m by n random numbers between 1 and (5+last two digits of unique id) by assuming m as first digit and n as last digit of your unique id. Assign a2 for the answer.
xiii) Display the number of rows and columns of a2.
xiv) Construct a 3 by 3 matrix by adding 1 and 5 in front of your unique id and assign a3.
xv) Construct a matrix a4 with the following conditions:
xvi) First three rows are same as of a3
xvii) Fourth row is 1.5 times of 2nd row of a3
xviii) Fifth row is sum of 1st and 3rd row of a3
xix) Sixth row is elementwise multiplication of 1st and 2nd row of a3
xx) Seventh row is transpose of elementwise multiplication of 1st and 3rd column of a3
xxi) Arrange a4 corresponding to maximum to minimum value of 3rd column and assign as a5.

- xxii) Assume last column of a4 as objective value and first two columns are parameters, display the parameters corresponding to the minimum objective value.
- xxiii) Display the average value of parameters given in a4 as first two columns.
- xxiv) Select the parameters value corresponding to first column of a2 as row of a4.

P-10

UNIT III

- i) Assign first two digits and last two digits of your unique id as b1 and b2 respectively. Calculate c1 as $b1 - b2$ if b1 greater than b2, otherwise $c1$ as $b1 * b2$. Display c1 value.
- ii) Using for loop, display the value of $i*5$ where i starts from last digit to first two digits of your unique id.
- iii) Generate 10 set of parameters values as per the following conditions.
- iv) Factor A lower limit and upper limit are last and first two digits
- v) Factor B lower limit and upper limit are sixth digit and 3rd & 4th digits
- vi) Read five students Physics, Chemistry and Maths marks as (70+fifth digit), (80+sixth digit) and (90+last digit) respectively from your unique id using while loop and calculate the total marks and average marks of each students. Display the answer. Assign t_marks and a_marks variable names for total and average marks.
- vii) Calculate the grade of the student based on the a_marks as per the following condition using switch statement.
 - a. <50 Second class
 - b. ≥ 50 and <75 First Class
 - c. ≥ 75 Distinction

P-10

TOTAL: 60 PERIODS

COURSE CODE	EXPERIMENTAL DESIGN, OPTIMIZATION AND VALIDATION	L	T	P	C
10213ME109		3	0	0	3

1. Preamble

This course imparts the knowledge in establishing an experimental design for developing new products/processes as well as for improving the quality of existing products/processes and also to find out the effect of input variables on the output /performance of the product/process and its optimum settings.

2. Pre-requisite

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the way of design the experiments in an efficient way.
- Understand the modern methods of optimization techniques used for solving engineering problems.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Understand the importance of experimentation	K2
CO2	Understand the process of designing the experiments using single factor	K2
CO3	Understand the process of designing the experiments using multi-factors	K2
CO4	Understand the usage of optimization techniques in solving the engineering problems	K2
CO5	Use the Minitab/Design Expert software for validating the designed experiments	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	H	H								
CO2	H	H	H	H								
CO3	H	H	H	H								
CO4	H	H	H	H								
CO5	H	H	H	H								

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I EXPERIMENTAL DESIGN FUNDAMENTALS

L-9

Introduction and Importance of experiments, basic principles of design, terminology, Steps in experimentation, normal probability plot, linear regression models.

UNIT II SINGLE FACTOR EXPERIMENTS

L-9

Statistical model, ANOVA, Completely randomized design, Randomized block design, Latin square design. Statistical analysis, estimation of model parameters, model validation, analysis of treatment of means.

UNIT III MULTIFACTOR EXPERIMENTS

L-9

Two and three factor full factorial experiments, 2^k factorial experiments, orthogonal array, statistical analysis, estimation of model parameters. Response surface methodology - basics, types, steps, benefits.

UNIT IV OPTIMIZATION

L-9

Introduction, optimal problem definition, classification of optimization problems, objective function, decision variable, constraints, statistical optimization techniques – desirability, grey relational analysis.

UNIT V VALIDATION

L-9

Create, analyze, visualize and validate the designed experiment using Minitab/ Design expert software.

TOTAL: 45 PERIODS

8. Text Books

1. Krishnaiah, K. and Shahabudeen, P. "Applied Design of Experiments and Taguchi Methods", PHI Learning Private Ltd., 2012.
2. Montgomery, D.C., "Design and Analysis of experiments", John Wiley and Sons, Eighth Edition, 2013.
3. Kalyanmoy Deb, "Optimization for Engineering Design", PHI, 2000

9. References

1. Nicolobelavendram, "Quality by Design; Taguchi techniques for industrial experimentation", Prentice Hall, 1995.
2. PhillipJ.Rose, "Taguchi techniques for quality engineering", McGraw Hill, 2005.
3. Montgomery, D.C., "Design and Analysis of Experiments, Minitab Manual", John Wiley and Sons, Seventh Edition, 2012.
4. Gwo-HshiungTzeng and Jih-Jeng Huang, "Multiple attribute decision making methods and applications", CRC press, A Chapman & Hall Book, 2011.

COURSE CODE	SOLAR THERMAL TECHNOLOGY	L	T	P	C
10213ME110		3	0	0	3

1. Preamble

This course delivers a knowledge of thermal systems in the solar energy domain. Students may gain knowledge on various applications of solar energy such as solar panel cooling, water heating, space heating and cost and estimation of solar system economics.

2. Pre-requisite

NIL

3. Link to the other courses

Solar energy engineering

Renewable sources of energy

Power plant engineering

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the basic principles of thermal technology in various solar thermal systems.
- Understand the solar applications of various systems such as Hot water generation, space heating, distillation and other applications related to solar energy.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Explore the meaning and kinds of solar collectors, storage tank and collector heat exchange factor	K2
CO2	Explain the working principle of various solar water heating systems	K2
CO3	Describe the solar space conditioning systems, heat storage configurations and refrigeration systems	K2
CO4	Elaborate the solar applications such as solar cooking, chimney and pumping systems and etc	K2
CO5	Understand the importance of cost and estimation of solar systems and its power generation	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

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

(H- High; M-Medium; L-Low)

7. Course Content**UNIT I SOLAR COLLECTORS****L-9**

Introduction to Solar energy - Flat plate - Evacuated tube – Concentrated - Pool and Air collectors Construction – Function - Suitability – Comparison - Storage Tank - Solar Fluids – Collector Heat Exchanger Factor.

UNIT II SOLAR LIQUID AND AIR HEATING SYSTEMS**L-9**

Natural, Forced circulation systems, Integral Collector Storage System - Thermosyphon System - Open Loop, Drain Down, Drain Back, Antifreeze Systems - Refrigerant Solar Water Heaters - Solar Heated Pools, Flat plate collector – Liquid and air heating, Bi fluid systems, Thermal analysis of the systems.

UNIT III SOLAR SPACE CONDITIONING SYSTEMS**L-9**

Liquid Type Solar Heating System With / Without Storage - Heat Storage Configurations – Heat Delivery Methods - Air-Type Solar Heating Systems - Solar Refrigeration and Air Conditioning.

UNIT IV OTHER SOLAR APPLICATIONS**L-9**

Solar Cooking – Distillation - Desalination - Solar Ponds – Solar greenhouse – Solar Drying – Solar Chimney – Swimming Pool Heating – Retrofit Water Heaters – Solar systems for Industrial process heat applications.

UNIT V SOLAR POWER PLANTS**L-9**

Solar thermal power plants - Parabolic trough system, distributed collector, hybrid solar-gas power plants, solar pond based electric-power plant, central tower receiver power plant, Solar PV power plants.

TOTAL: 45 PERIODS**8. Text Books**

1. J.A. Duffie, W.A. Beckman, Solar Engineering of Thermal Processes, John Wiley Interscience, New York, 2013.
2. Goswami, D. Y., Principles of Solar Engineering, 3rd Edition, CRC Press, 2015.

9. References

1. H P Garg, M Dayal, G Furlan, Physics and Technology of Solar Energy- Volume I: Solar Thermal Applications, Springer, 2017.
2. Sukhatme and Nayak, Solar Energy: Principles Of Thermal Collection And Storage, Tata McGraw.Hill, 2008.

3. Bob Ramlow & Benjamin Nusz, Solar Water Heating, New Society Publishing, 2006.
4. John Canivan, Solar Thermal Energy, Sunny Future Press - 2003.
5. Charles Christopher Newton - Concentrated Solar Thermal Energy- Published by VDM Verlag, 2008.
6. H.P.Garg, S.C.Mullick, A.K.Bhargava, D.Reidal, Solar Thermal Energy Storage Springer, 2005.
7. Kalogirou .S.A., "Solar Energy Engineering: Processes and Systems", Academic Press, 2009.
8. Vogel. W, Kalb .H, "Large-Scale Solar Thermal Power Technologies", Wiley-VCH, 2010.
9. G. N. Tiwari, Solar Energy: Fundamentals, Design, Modelling and Application (Revised Edition), Narosa Publishing House Pvt. Ltd., 2013.

COURSE CODE	ENERGY CONSERVATION AND AUDIT	L	T	P	C
10213ME111		3	0	0	3

1. Preamble

To enable the students to acquire the knowledge of energy conservation measures in thermal and electrical energy systems. To familiarize the students about energy conservation and energy audit. To familiarize the students with the concept of energy conservation and management.

2. Pre-requisite

Basic Electrical Engineering

3. Link to the other courses

Project work

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the energy management concepts
- Energy conservation principles and measures
- Learn the methods of energy audit and usage of instruments
- Analyze and report the outcome of energy audit

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Identify the energy demand supply gap in the World & India and understand energy conservation opportunities available	K2
CO2	Quantify the energy conservation opportunities in different thermal systems	K3
CO3	Quantify the energy conservation opportunities in different electrical systems	K3
CO4	Identify and evaluate the common energy conservation opportunities in different energy intensive industrial equipment	K3
CO5	Understand the need for energy audit and examine the economic evaluation of energy conservation solutions adopted	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M					L	L				L	L
CO2	M					L	L				L	L
CO3	M					L	L				L	L
CO4	M					L	L				L	L

CO5	M					L	L				L	L
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(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION TO ENERGY CONSERVATION L-9

Principles - Past and present energy scenario of world – Energy consumption in India – resource availability – Demand supply gap - Environmental aspects–Energy Conservation act – Standards and labeling – designated consumers.

UNIT II ENERGY CONSERVATION IN DOMESTIC AND COMMERCIAL SPACE L-9

Building science and its significance – Human comfort - Quality of indoor environment – Energy efficient landscape – Energy management of buildings - Energy audit of buildings.

UNIT III FUNDAMENTALS OF ELECTRICAL ENERGY AND AUDIT L-9

Components of EB billing - types of tariff – HT and LT supply – Transformers – cable selection – power factor improvement – capacitors – harmonics – electric motors – efficiency – energy efficient motors – variable speed drives - lighting – types- efficacy.

UNIT IV ENERGY CONSERVATION IN INDUSTRIES L-9

Energy conservation in industrial equipment – Waste heat recovery – Effectiveness of Industrial process – Obsolete equipment and trending technology– Industrial revolution in India.

UNIT V ENERGY AUDIT AND ENERGY ECONOMICS L-9

Energy audit -need – types - benefits - methodology and barriers – role of energy managers – instruments for energy auditing; Energy economics – discount rate – depreciation cost - payback period – internal rate of return – net present value – life cycle costing – case study.

TOTAL: 45 PERIODS

8. Text Books

1. Kennedy, William J., Turner, Wayne C., and Capehart, Barney L., Guide to Energy Management, The Fairmount Press.
2. Callaghan, P.W., Design and Management for Energy Conservation”, Pergamon Press, Oxford.
3. Sodha M., Bansal N.K., Bansal P.K., Kumar A.. and Malik M.A.S., "Solar Passiv Buildings”, Pergamon Press.

9. References

1. Dryden, I.G.C., The Efficient Use of Energy, Butterworths, London
2. Turner, W.C., Energy Management Handbook, Wiley, New York (1982)
3. Energy Manager Training Manual (www.energymanagertraining.com)
4. Givoni, B., "Man, Climate and Architecture”, Elsevier, Amsterdam, 1986.
5. Smith, R. J., Phillips, G.M. and Sweeney, M. "Environmental Science”, Longman Scientific and Technical, Essex, 1982.

COURSE CODE	ENERGY MANAGEMENT	L	T	P	C
10213ME112		3	0	0	3

1. Preamble

This course provides an update, to the knowledge base of the students, in essential Energy Management. Students may gain knowledge on Energy Auditing, Waste Heat Recovery, HVAC, Lighting systems and Maintenance of Energy Systems.

2. Pre-requisite

NIL

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the basic principles of Energy Auditing and its types involved in Energy Sector.
- Understand the Energy Management Concepts in Waste Heat Recovery Systems, HVAC Systems, Lighting Systems etc. and to gain knowledge about the maintenance of Energy Systems.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Explain the meaning and types of Energy Consuming Devices and concept of Energy Management	K2
CO2	Describe the principle of Energy Auditing and Economic aspects of investments	K2
CO3	Elaborate the Waste Heat Recovery Concepts and Energy Conservation methods in HVAC Systems	K2
CO4	Understand and implement the Energy Conservation options in Lighting systems	K2
CO5	Explore ECBC and the concepts of energy conservation in buildings.	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1									H		M	L
CO2									H		M	L
CO3									H		M	L
CO4									H		M	L
CO5									H		M	L

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION TO ENERGY MANAGEMENT L-9

Basics of energy and its various forms - Introduction to Energy Consuming Devices – Energy Management – Effective Energy Management – Top Management Commitment and Support – Energy Manager – Responsibilities and Duties – Integrated Energy Policy - National Action Plan on Climate Change – Guiding principle – Eight National Missions.

UNIT II ENERGY AUDITING AND ECONOMIC ANALYSIS L-9

Energy Audit – Definition – Need, Types of energy audit – Understanding energy costs – Energy audit report – Benchmarking – Instrumentation and metering for energy audit – BEE Regulations – Industrial Audits – Commercial Audits – Residential audits – Economic Analysis – Simple Payback Period – Return on Investment – Net Present Value method – Future Value method.

UNIT III WASTE HEAT RECOVERY AND HVAC SYSTEMS L-9

Waste Heat Recovery – Classification and Application – Benefits of Waste Heat Recovery – Development of a Waste Heat Recovery System – Cogeneration – Commercial Waste Heat Recovery Devices – Heat Exchangers – Concept – Types, by flow design, by construction, by application – Human Thermal Comfort – HVAC System Types – Cooling Equipment – Energy Conservation Opportunities.

UNIT IV LIGHTING SYSTEM L-9

Lighting Fundamentals – Basic Parameters and Terms in Lighting System – Light Source and Lamp types – Illuminance levels – Lighting design for interiors – General energy saving opportunities Energy efficient lighting controls Standards and labelling programs for FTL Lamps – Day Lighting – Use of Alternative Energy – Solar Energy – Wind Energy.

UNIT V ENERGY CONSERVATION IN BUILDINGS AND ECBC L-9

Building definition – Energy Conservation Building Code – Compliance approaches – ECBC guidelines on building envelop – ECBC guidelines on service hot water – ECBC guidelines on lighting – ECBC guidelines on electrical power – Building water pumping systems – Uninterruptible power supply – Building Management Systems – Star rating of Buildings – Energy efficiency measures in Buildings.

TOTAL: 45 PERIODS

8. Text Books

1. General Aspects of Energy Management and Energy Audit - Guide book for National Certification Examination for Energy Managers and Energy Auditors, by Bureau of Energy Efficiency, Fourth Edition, 2015.
2. Energy Efficiency in Thermal Utilities – Guide book for National Certification Examination for Energy Managers and Energy Auditors, by Bureau of Energy Efficiency, Fourth Edition, 2015.
3. Energy Efficiency in Electrical Utilities Book 03 Final - Guide book for National Certification Examination for Energy Managers and Energy Auditors, by Bureau of Energy Efficiency, Fourth Edition, 2015.
4. Energy Management Handbook, Vol I and II, Wayne C. Turner, Steve Doty, Eighth Edition, 2013, Fairmont Press.

9. References

1. Handbook of Energy Audit, Sonal Desai, Mc Graw Hill Education.
2. Energy Engineering and Management, Amlan Chakrabarti, PHI.
3. Energy Management Handbook, Jonathan H Turner.
4. Study Materials from e-Sources, related to Energy Management.

COURSE CODE	GREEN ENGINEERING AND SUSTAINABILITY	L	T	P	C
10213ME113		3	0	0	3

1. Preamble

The course is designed to provide the an increased awareness among students about various renewable energy sources and issues in areas of sustainability and to establish a clear understanding of the role and impact of various aspects of engineering and engineering decisions on environmental, societal, and economic issues.

2. Pre-requisite

NIL

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the various sources of renewable energy.
- Get an understanding of the engineering decisions and its impacts on environmental, societal, and economic problems.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Explain the concepts of green energy and sustainability	K2
CO2	Identify the uses of solar and wind energy sources with respect to sustainability	K2
CO3	Elaborate the uses of biomass, ocean & geothermal energy sources	K2
CO4	Describe the underlying principles of environmental sustainability	K2
CO5	Explore about pollution and waste management	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

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

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I GREEN ENERGY AND SUSTAINABILITY

L-9

Energy Scenario in India, Introduction to Green Energy – Basic concepts, Green

UNIT II APPLICATIONS OF SOLAR AND WIND ENERGY L-9

UNIT III MINOR GREEN ENERGY SOURCES L-9

UNIT IV ENVIRONMENTAL SUSTAINABILITY TOOLS L-9

UNIT V POLLUTION & CONTROL STRATEGIES L-9

TOTAL: 45 PERIODS

1. Godfrey Boyle, "Renewable Energy – Power for a Sustainable Future", 2nd Edition, Oxford University Press.
2. Atul Sharma (Editor), Sanjay Kumar Kar (Editor), "Energy Sustainability through Green Energy", Springer, May 2015.

1. Aldo V. da Rosa, "Fundamentals of Renewable Energy Processes", 2005, Academic Press.
2. John W Twidell and Anthony D Weir, Renewable Energy Resources, English Language Book Society (ELBS) 1996.
3. D P Kothari, K C Singal, Rakesh Ranjan, Renewable Energy Sources and Emerging Technologies, Prentice Hall of India
4. S.S Purohit , Green Technology-An approach for sustainable environment. Agrobios publication
5. Mihelcic, J. R. and Zimmerman, J. B., Environmental Engineering, Wiley Publishers.
6. Brennen, D. Sustainable Process Engineering, Pan Stanford Publishers.

COURSE CODE	FACILITY LAYOUT AND MATERIAL HANDLING	L	T	P	C
10213ME114		3	0	0	3

1. Preamble

To understand basic layout for industries, the usage of material handling equipment's for industrial layout and gain knowledge on industrial buildings and utilities.

2. Pre-requisite

NIL

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the concept of facility location and design
- Understand the concept of computerized layout planning.
- Know about the various material handling equipment and utilities of the industries.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Demonstrate the knowledge about types of facility location problems and various models.	K2
CO2	Design the plant layout	K3
CO3	Demonstrate the knowledge about computerized layout planning and line balancing techniques.	K2
CO4	Know the different types of material handling equipment and packing systems.	K2
CO5	Know the effective selection and contribution of utilities for buildings.	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H						L				L	L
CO2	H						L				L	L
CO3	H				M		L				L	L
CO4	H						L				L	L
CO5	H						L				L	L

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I FACILITY LOCATION

L-9

Introduction , Factors affecting location decisions , Location theory , Qualitative models , Semi- Quantitative models -Composite measure , Brown & Gibbs model , Break-Even analysis model, Single facility location problems – Median model,

Gravity location model, Mini-Max model, Multi-facility location problems, Network and warehouse location problems.

UNIT II FACILITY LAYOUT DESIGN

L-9

Need for layout study , Factors influencing plant layout ,Objectives of a good facility layout, Classification of layout , Layout procedure – Nadler’s ideal system approach, Immer’s basic steps, Apple’s layout procedure, Reed’s layout procedure –Layout planning – Systematic layout planning – Information gathering, flow analysis and activity analysis, relationship diagram, space requirements and availability, designing the layout, Utilities planning.

UNIT III COMPUTERISED LAYOUT PLANNING

L-9

Concepts, Designing process layout –CRAFT, ALDEP, CORELAP, PLANET – Trends in computerized layout, Algorithms and models for Group Technology - ROC and Bond Energy Algorithms. Line balancing - Objectives, Line balancing techniques – Largest Candidate rule Kilbridge and Wester method- RPW method- COMSOAL

UNIT IV MATERIAL HANDLING

L-9

Objectives and benefits of material handling, Relationship between layout and material handling, Principles of material handling, Unit load concept, Classification of material handling equipment’s, Equipment selection, Selection of material handling systems and equipment’s. Automated Guided Vehicles, types, features, usage. Conveyors: basic functionality requirements, types of conveyors, application considerations, operational considerations. Cranes, hoists and industrial trucks.

UNIT V ANALYSIS OF MATERIAL HANDLING

L-9

Motion analysis, flow analysis, graphic analysis, safety analysis, equipment cost analysis, palletization analysis- analysis of operation- material handling surveys.

TOTAL: 45 PERIODS

8. Text Books

1. James, M. Apple., „Plant Layout and Material Handling“, John Wiley & Sons, INC, 1977.
2. Rudenko. N., “Materials handling equipment”, Elnvee Publishers, 1970.
3. Francis, R.L., and White, J.A. Facilities layout and Location, Prentice Hall of India, 2002.

9. References

1. James, M. Moore, „Plant Layout and Design“, Macmillan Company, NY, 1963
2. Muther, R., „Practical Plant Layout“, Mc Graw Hill Book Company, NY, 1955
3. Tompkins, White et al., Facilities planning, John Wiley & Sons, inc. 2003.
4. James, Apple, Material Handling System design, Ronald Press, 1980.
5. Krajewski, J. and Ritzman, Operations Management – Strategy and Analysis, Addison – Wesley publishing company inc. 5th Edition, 1999.
6. Pannerselvam,R. Production & operations Management, PHI, 2nd Edition, 2005.

COURSE CODE	INDUSTRIAL SAFETY, HEALTH AND HAZARDS	L	T	P	C
10213ME115		3	0	0	3

1. Preamble

This course provides an introduction about industrial safety, health and hazards where an engineer is going to be employed in his professional life. It also enhances his ability to deal with various situations during his stay in industry.

2. Pre-requisite

NIL

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- Understand about Industrial Safety Management
- Possess knowledge on accident prevention and investigation
- Understand about various Hazards in workplace
- Gain the knowledge on Occupational Health Hazards

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Discuss about various techniques Industrial Safety Management	K2
CO2	Explain about accident prevention and investigation techniques.	K2
CO3	Identify the hazards in engineering and construction industries	K2
CO4	Identify the general hazards in chemical industries	K2
CO5	Possess knowledge on Control of Occupational Health Hazards	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H					M	L	L		L		
CO2	H					M	L	L				
CO3	H					M	L	L				L
CO4	H					M	L	L				L
CO5	H					M	L	L				L

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I SAFETY MANAGEMENT

L-9

History and development of safety movement Need for safety, Safety policy: safety organization and responsibilities and authorities of different levels. Safety Committee – Unsafe Act and Unsafe Conditions - Behaviour based Safety - Safety training – creating awareness, awards, celebrations, safety posters, safety displays, safety pledge, safety incentive scheme, safety campaign - budgeting for safety. Introduction to legal requirements - Introduction to ISO 45001.

UNIT II ACCIDENT PREVENTION AND INVESTIGATION

L-9

Concept of an accident, reportable and non-reportable accidents, reporting to statutory authorities – principles of accident prevention – accident investigation and analysis – records for accidents, departmental accident reports, documentation of accidents – unsafe act and condition – domino sequence – supervisory role – cost of accident.

UNIT III SAFETY IN CONSTRUCTION AND ENGINEERING INDUSTRIES L-9

Machine Guarding, Guarding of hazards, Machine Guarding types and its application – Safety in welding and Gas cutting – Safety in Manual and Mechanical material handling- safety with hand tools/ portable power tools, Pressure vessel hazards and their control, safety with storage of materials, Construction: Work at Height, Excavation, heavy equipment, Safety in use of electricity, LOTO (Lockout-Tagout)

UNIT IV SAFETY IN PROCESS INDUSTRY AND FIRE SAFETY

L-9

Chemical hazards: laboratory safety, bulk handling of chemicals, confined space entry, Work Permit System, Fire and explosion hazards, Chemical Toxic hazards, Introduction to Process Safety Management.

Fire triangle- Chemistry of Fire - Types of fire - first aid firefighting equipment – Fire detection, Prevention, control, and extinguishments – Introduction to Onsite and Offsite Emergency Plan.

UNIT V PREVENTION OF OCCUPATIONAL HEALTH HAZARDS

L-9

Physical Hazards: Noise, Heat Stress, Vibration, Control measures for Physical Hazards – Chemical Hazards: Types of Chemical Hazards, TLV, Occupational diseases caused by dust, fumes, gases, smoke and solvent hazards, control measures – Ergonomical Hazards; Back Pain, Manual Handling, carpal tunnel syndrome, control measures – Introduction to Biological Hazards, Biological safety cabins - Hazard identification and Risk Assessment - Personal protective equipment's.

TOTAL: 45 PERIODS

8. Text Books

1. R.K.Jain and Sunil S.Rao , Industrial Safety, Health and Environment Management Systems, Khanna publishers , New Delhi (2006)
2. Slote.L. Handbook of Occupational Safety and Health, John Willey and Sons, NewYork.

9. References

1. Grimaldi and Simonds , Safety Management, AITBS Publishers , New Delhi (2001)
2. Accident Prevention Manual for Industrial Operations”, N.S.C.Chicago, 1982
3. Blake R.B., “Industrial Safety” Prentice Hall, Inc., New Jersey, 1973
4. Heinrich H.W. “Industrial Accident Prevention” McGraw-Hill Company, New York, 1980.
5. Krishnan N.V. “Safety Management in Industry” Jaico Publishing House, Bombay, 1997.
6. John Ridley, “Safety at Work”, Butterworth & Co., London, 1983.

COURSE CODE	OPTIMIZATION TECHNIQUES	L	T	P	C
10213ME116		3	0	0	3

1. Preamble

To provide comprehensive knowledge about the optimization techniques for engineering problems.

2. Pre-requisite

Engineering Mathematics II

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- To understand and apply the various traditional optimization techniques to solve engineering problems.
- To understand and apply the various non-traditional optimization techniques to solve engineering problems.
- Serve as a prerequisite for the project work and specialized studies during research.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Develop the real world problem in to optimization problem and solve them using various optimization techniques.	K3
CO2	Solve engineering problems using classical optimization techniques.	K3
CO3	Apply the techniques of unconstrained optimization in real world problem.	K3
CO4	Solve engineering problems using constrained optimization techniques.	K3
CO5	Solve engineering problems using unconventional optimization techniques.	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M				M	L	M	L	L	H	L	H
CO2	M				M	L	M	L	L	H	L	H
CO3	M	L	L	L	M	L	M	L	L	H	L	H
CO4	M				M	L	M	L	L	H	L	H
CO5	M				M	L	M	L	L	H	L	H

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION

L-9

Introduction to optimization - General principles – Classification - Problem formulation & their classifications.

UNIT II CLASSICAL OPTIMIZATION TECHNIQUES

L-9

Single variable and multivariable optimization Single and Multi-objectives -Pareto Optimal solutions.

UNIT III UNCONSTRAINED OPTIMIZATION TECHNIQUES

L-9

Techniques of unconstrained optimization – Golden section, Random, Pattern and Gradient search methods – Interpolation methods.

UNIT IV CONSTRAINED OPTIMIZATION TECHNIQUES

L-9

Optimization with equality and inequality constraints - Direct methods – Indirect methods using penalty functions.

UNIT V UNCONVENTIONAL OPTIMIZATION TECHNIQUES

L-9

Genetic Algorithms, Particle Swarm Optimization, Simulated Annealing and Ant Colony algorithm.

TOTAL: 45 PERIODS

8. Text Books

1. S.S. Rao, “Engineering Optimization – Theory & Practice”, New Age International (P) Limited, New Delhi, 2009.

9. References

1. Kalyanamoy Deb, “Optimization for Engineering Design Algorithms and Examples”, Prentice Hall of India Pvt. Ltd., 2006.
2. C. Johnson Ray, “Optimum Design of Mechanical Elements”, Wiley, John & Sons, Digitized 2007.
3. D.E.Goldberg, “Genetic Algorithms in Search, Optimization and Machine”, Barnen, Addison Wesley, New York, 1989.
4. C. S. Rao, “Optimization Techniques”, Dhanpat Rai & Sons, New Delhi

Honors & Minor

B.Tech. HONORS

Theme 1: Digital Manufacturing

COURSE CODE	AUTOMATION IN MANUFACTURING	L	T	P	C
10212ME160	AND CIM	3	0	0	3

1. Preamble

This course provides insight into various automated systems; NC, CNC part programming, and support systems used for inspection in the manufacturing industry.

2. Pre-requisite

10211ME204-Manufacturing Technology

3. Link to the other courses

Project work

4. Course Educational Objectives

Students, after undergoing this course would

- To understand the various Automation systems and material handling techniques
- To develop computer-aided part programming and computer-aided process planning

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Explain the basic elements of automated systems and hardware requirements for automation	K2
CO2	Identify suitable material handling equipment and techniques for automated storage systems.	K2
CO3	Describe the single station-manufacturing cell, automated production line types, and its application in a manufacturing system.	K2
CO4	Develop computer-aided part programming and tool path generation for the given drawing.	K3
CO5	Explain the optical and Artificial Intelligence methods in computer-aided inspection and quality control.	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M											M	
CO2	H	H	L										M	
CO3	M	H												
CO4	H	H	H		H			L					H	H
CO5	H	M											H	L

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I OVERVIEW OF MANUFACTURING AND AUTOMATION L-9

Production systems, Automation in production systems, Automation principles and strategies, Manufacturing operations, production facilities. Basic elements of an automated system, levels of automation; Hardware components for automation and process control, programmable logic controllers and personal computers.

UNIT II MATERIAL HANDLING AND IDENTIFICATION TECHNOLOGIES L-9

Material handling, equipment, Analysis. Storage systems, performance and location strategies, automated storage systems, AS/RS, types. Automatic identification methods, Barcode technology, RFID.

UNIT III MANUFACTURING SYSTEMS AND AUTOMATED PRODUCTION LINES L-9

Manufacturing systems: components of a manufacturing system, Single station manufacturing cells; Manual Assembly lines, line balancing Algorithms, Mixed model Assembly lines, Alternative Assembly systems. Automated production lines, Applications, Analysis of transfer lines.

UNIT IV COMPUTE-AIDED PROGRAMMING L-9

General information, APT programming, Examples Apt programming problems (2D machining only). NC programming on CAD/CAM systems, the design and implementation of post processors .Introduction to CAD/CAM software, Automatic Tool Path generation.

UNIT V QUALITY CONTROL AND SUPPORT SYSTEMS L-9

Hybrid CAAP System, Computer Aided Inspection and quality control, Coordinate Measuring Machine, Limitations of CMM, Computer Aided Testing, Optical Inspection Methods, Artificial Intelligence and expert system: Artificial Neural Networks, Artificial Intelligence in CAD.

TOTAL: 45 PERIODS

8. Text Books

1. Automation, production systems and computer integrated manufacturing/ Mikell.P Groover/PHI/3rd edition/2012.
2. Computer Control of Manufacturing Systems / YoramKoren / McGraw Hill. 1983.

9. References

1. Automation, Production Systems and CIM/ Mike J P. Grower/PHI
2. CAD/CAM/CIM/ P. Radha Krishnan & S. Subrahmanyarn and Raju/New Age International Publishers/2003.Computer Aided Design Manufacturing – K. Lalit Narayan, K. Mallikarjuna Rao and M.M.M. Sarcar, PHI, 2008.

COURSE CODE	COMPUTER AIDED DESIGN AND MANUFACTURING	L	T	P	C
10212ME161		3	0	0	3

1. Preamble

This course provides a fundamental understanding of CAD/CAM and to Apply CAD/CAM concept to Product Design and Manufacturing.

2. Pre-requisite

10211ME204-Manufacturing Technology

3. Link to the other courses

Project work

4. Course Educational Objectives

Students, after undergoing this course would

- To understand the use of CAD/CAM systems and standards in Manufacturing and Design
- To develop part programming by understanding the fundamental knowledge of G-code and M-code

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Summarize the graphic user interface devices, 2-D & 3-D transformation, and CAD/CAM systems manufacturing models.	K2
CO2	Draw and generate special curves using Bezier, B-spline, rational, and surface modeling techniques	K3
CO3	Describe the CAD standards and exchange format for data and image transformation in computer graphics	K2
CO4	Write manual part programming for CNC lathe and milling machine using G-codes and M-codes.	K3
CO5	Explain group technology, part family, components of flexible manufacturing system, and solve simple problems using Optiz coding system.	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M	L										H	L
CO2	M	M	H		L					L			H	H
CO3	M	M					M	M				L	L	
CO4	H	M	L				L					L		
CO5	H	M	L										M	M

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION

L-9

Product cycle- Design process- sequential and concurrent engineering- Computer aided design – CAD system architecture- Computer graphics – co-ordinate systems- 2D and 3D transformations- homogeneous coordinates - Line drawing -Clipping-viewing transformation- Introduction to CAD/CAM –CAD/CAM concepts —Types of production - Manufacturing models and Metrics – Mathematical models of Production Performance.

UNIT II GEOMETRIC MODELING

L-9

Representation of curves- Hermite curve- Bezier curve- B-spline curves-rational curves-Techniques for surface modeling – surface patch- Coons and bicubic patches- Bezier and B-spline surfaces. Solid modeling techniques- CSG and B-rep.

UNIT III CAD STANDARDS

L-9

Standards for computer graphics- Graphical Kernel System (GKS) - standards for exchange images- Open Graphics Library (OpenGL) - Data exchange standards - IGES, STEP, CALS etc. - communication standards.

UNIT IV FUNDAMENTAL OF CNC AND PART PROGRAMMING

L-9

Introduction to NC systems and CNC - Machine axis and Co-ordinate system- CNC machine tools- Principle of operation CNC- Construction features including structure- Drives and CNC controllers- 2D and 3D machining on CNC- Introduction of Part Programming, types - Detailed Manual part programming on Lathe & Milling machines using G codes and M codes- Cutting Cycles, Loops, Sub program and Macros- Introduction of CAM package.

UNIT V CELLULAR MANUFACTURING AND FLEXIBLE MANUFACTURING SYSTEM (FMS)

L-9

Group Technology(GT),Part Families–Parts Classification and coding–Simple Problems in Opitz Part Coding system–Production flow Analysis–Cellular Manufacturing– Composite part concept–Types of Flexibility - FMS – FMS Components – FMS Application & Benefits – FMS Planning and Control– Quantitative analysis in FMS.

TOTAL: 45 PERIODS

8. Text Books

1. Ibrahim Zeid “Mastering CAD CAM” Tata McGraw-Hill PublishingCo.2007
2. Mikell.P.Groover “Automation, Production Systems and Computer Integrated Manufacturing”, Prentice Hall of India, 2008.
3. Radhakrishnan P, SubramanyanS. And Raju V., “CAD/CAM/CIM”, 2nd Edition, New Age International (P) Ltd, New Delhi, 2000.

9. References

1. Chris McMahon and Jimmie Browne “CAD/CAM Principles”, "Practice and Manufacturing management “ Second Edition, Pearson Education, 1999.
2. Donald Hearn and M. Pauline Baker “Computer Graphics”. Prentice Hall, Inc, 1992.
3. Foley, Wan Dam, Feiner and Hughes - "Computer graphics principles &

practice" Pearson Education -2003

4. William M Neumann and Robert F.Sproul "Principles of Computer Graphics", McGraw Hill Book Co. Singapore, 1989.

COURSE CODE	PRECISION ENGINEERING	L	T	P	C
10212ME162		3	0	0	3

1. Preamble

This course provides a precision manufacturing methods and applications of Lasers in Precision measuring systems.

2. Pre-requisite

NIL

3. Link to the other courses

Project work

4. Course Educational Objectives

Students, after undergoing this course would

- To understand the various precision manufacturing methods and documentation for precision equipment
- To study the applications of Lasers in Precision measuring systems.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Explain the accuracy requirements in machines and errors in numerical positioning	K2
CO2	Illustrate the types and datum positioning for computation of accuracy and geometry analysis	K3
CO3	Apply moments, sure fit, normal, and truncated normal laws for tolerance analysis	K3
CO4	Apply tolerance charting techniques for tolerance analysis	K3
CO5	Apply mechanical and optical measurement techniques to measure in-situ dimensional features	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M											H	
CO2	H	M											H	
CO3	H	M											H	
CO4	H	M	L										H	M
CO5	H	M	L		M								H	M

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I CONCEPTS OF ACCURACY

L-9

Introduction – Concept of Accuracy of Machine Tools – Spindle and Displacement Accuracies – Accuracy of numerical Control Systems – Errors due to Numerical Interpolation Displacement Measurement System and Velocity lags.

GEOMETRIC DIMENSIONING AND TOLERANCING:

Tolerance Zone Conversions – Surfaces, Features, Features of Size, Datum Features – Datum Oddly Configured and Curved Surfaces as Datum Features, Equalizing Datums – Datum Feature of Representation – Form controls, Orientation Controls – Logical Approach to Tolerancing.

UNIT II DATUM SYSTEMS

L-9

Design of freedom, Grouped Datum Systems – different types, two and three mutually perpendicular grouped datum planes; Grouped datum system with spigot and recess, pin and hole; Grouped Datum system with spigot and recess pair and tongue – slot pair – Computation of Transnational and rotational accuracy, Geometric analysis and application.

UNIT III TOLERANCE ANALYSIS

L-9

Process Capability, Mean, Variance, Skewness, Kurtosis, Process Capability Metrics, Cp, Cpk, Cost aspects, Feature Tolerances, Geometric Tolerances. Surface finish, Review of relationship between attainable tolerance grades and different machining process, Cumulative effect of tolerances sure fit law, normal law and truncated normal law.

UNIT IV TOLERANCE CHARTING TECHNIQUES

L-9

Operation Sequence for typical shaft type of components, Preparation of Process drawings for different operations, Tolerance worksheets and centrally analysis, Examples, Design features to facilitate machining; Datum Features – functional and manufacturing Components design – Machining Considerations, Redesign for manufactured, Examples.

UNIT V MEASURING SYSTEMS PROCESSING

L-9

In processing or in-situ measurement of position of processing point-Post process and on-machine measurement of dimensional features and surface mechanical and optical measuring systems.

TOTAL: 45 PERIODS

8. Text Books

1. Precision Engineering in Manufacturing/Murthy R.L. /New Age International (P) limited, 1996.
2. Geometric Dimensioning and Tolerancing / James D. Meadows / Marcel Dekker inc. 1995.
3. Nano Technology / Norio Taniguchi / Oxford University Press, 1996.
4. Engineering Design – A systematic Approach / Matousek / Blackie & Son Ltd., London
5. Precision Engineering/VC Venkatesh& S Izman/TMH

COURSE CODE	INDUSTRY 4.0 AND IoT	L	T	P	C
10212ME163		3	0	0	3

1. Preamble

This course provides comprehensive coverage of the role of data, manufacturing systems, various Industry 4.0 technologies, and applications.

2. Pre-requisite

NIL

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- To study the components and framework used in the industry and their role in an Industry 4.0
- To understand the real-time applications of Industry 4.0

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describe the development and present requirements of industry 4.0	K2
CO2	Outline the components and framework used in the industry 4.0	K2
CO3	Develop a framework of industry 4.0 for a new product and process	K3
CO4	Explain the needs and importance of lean, just in time, and agile production systems in Industry 4.0	K2
CO5	Explain the real-time applications of Industry 4.0 in the field of Machining, Casting, and Fabrication	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M												
CO2	H	M										M	M	
CO3	H	H	L		L							M	M	
CO4	M	M											L	
CO5	M	H											M	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION TO INDUSTRY 4.0

L-9

Introduction, core idea of Industry 4.0, origin concept of industry 4.0, Industry 4.0 production system, current state of industry 4.0, Technologies.

Introduction, Main Concepts and Components of Industry 4.0, State of Art, Supportive Technologies, Proposed Framework for Industry 4.0.

Introduction, Proposed Framework for Technology Roadmap, Strategy Phase, New Product and Process Development Phase.

Sustainability assessment of manufacturing, Lean Production system, Just in Time production system, Agile Manufacturing, Smart and Business perspective, collaboration platform and product life cycle.

Machining, Casting, and Fabrication industries Factories and assembly line, Food industry, Healthcare, Power plant, Production planning and control Inventory management and quality control, Plant security and safety, facility management.

8. Text Books

1. Bartodziej, Christoph Jan, the Concept Industry 4.0, Springer Cabler, Germany, 2016.
2. Alp Ustundag and EmreCevikcan, Industry 4.0: Managing the Digital Transformation, Springer international publishing, Switzerland, 2018.

1. Klaus Schwab, the Fourth Industrial Revolution, Switzerland, 2016
2. Christian Schröder, The Challenges of Industry 4.0 for Small and Medium-sized Enterprises, Germany, 2017.

COURSE CODE	ADDITIVE MANUFACTURING	L	T	P	C
10212ME164		3	0	0	3

1. Preamble

The main objective of this course is to acquaint students with the concept of AM, various AM technologies, selection of materials for AM, modeling of AM processes, and their applications in various fields.

2. Pre-requisite

NIL

3. Link to the other courses

Project work

4. Course Educational Objectives

Students, after undergoing this course would

- To understand the concept of reverse engineering
- To understand the constructional feature, principle, and applications of solid-based and powder-based additive manufacturing.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Differentiate direct and indirect rapid prototyping processes.	K3
CO2	Outline and select suitable material for the Additive manufacturing process based on the solidification rate.	K3
CO3	Illustrate the constructional features, principles, and applications of solid-based and powder-based additive manufacturing processes.	K3
CO4	Develop numerical models for additive manufacturing processes	K3
CO5	Select a suitable additive manufacturing process plan and defects control method for the given applications	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	H											L	
CO2	M	H					L	L					M	
CO3	H	M											L	
CO4	H	M											L	
CO5	M	H											M	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION TO ADDITIVE MANUFACTURING (AM) L-9

General overview: Introduction to reverse engineering and AM- Computer aided design (CAD) and manufacturing (CAM) in AM- AM Direct processes – Rapid Prototyping, Rapid Tooling, Indirect Processes - Indirect Prototyping. Indirect Tooling.

UNIT II MATERIALS SCIENCE FOR AM L-9

Discussion on different materials, multifunctional and graded materials in AM Role of solidification rate Evolution of non-equilibrium structure Structure property relationship Grain structure and microstructure.

UNIT III AM TECHNOLOGIES L-9

Powder-based AM processes involving sintering and melting (selective laser sintering, shaping, and electron beam melting. involvement). Printing processes (droplet based 3D Solid-based AM processes - extrusion based fused deposition modeling object Stereo lithography Micro- and Nano-additive.

UNIT IV MATHEMATICAL MODELS FOR AM L-9

Case studies: Numerical Modeling of AM process, Powder bed melting based process, Droplet based printing process Residual stress, part fabrication time, cost, optimal orientation and optimal Defect in AM and role of transport Simulations.

UNIT V PROCESS SELECTION, PLANNING, CONTROL FOR AM L-9

Selection of AM technologies using decision methods Additive manufacturing process plan: strategies and post processing. Monitoring and control of defects, transformation.

TOTAL: 45 PERIODS

8. Text Books

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

9. References

1. Liou L.W. and Liou F.W., "Rapid Prototyping and Engineering applications: A tool box for prototype development", CRC Press, 2007.
2. Kamrani A.K. and Nasr E.A., "Rapid Prototyping: Theory and practice", Springer, 2006.

COURSE CODE	INTELLIGENT MANUFACTURING	L	T	P	C
10212ME165	SYSTEMS	3	0	0	3

1. Preamble

This course provides adequate knowledge in planning manufacturing systems, computer integrated manufacturing and enterprise integration, group Technology and knowledge-based systems.

2. Pre-requisite

NIL

3. Link to the other courses

Project work

4. Course Educational Objectives

Students, after undergoing this course would

- To understand the structure, components and functional areas of the Intelligent Manufacturing System
- To understand the importance, applications, and types of artificial Neural Networks in manufacturing.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Explain the structure, components, and functional areas of the computer integrated manufacturing system	K2
CO2	Describe and compare the knowledge-based systems and their representation scheme in Intelligent manufacturing system	K3
CO3	Outline the importance, applications, and types of artificial neural networks in manufacturing	K2
CO4	Develop a systematic approach for the design and implementation of manufacturing systems using variant, generative and expert systems models	K3
CO5	Develop models and algorithms for group technology using visual, coding, and cluster analysis method	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	M												
CO2	M	H											L	
CO3	M	H												
CO4	H	H	L										M	L
CO5	H	H	L										M	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I CIM SYSTEMS

L-9

Computer Integrated Manufacturing Systems Structure and functional areas of CIM system, CAD, CAPP, CAM, CAQC, ASRS. Advantages of CIM. Manufacturing Communication Systems - MAP/TOP, OSIModel, Data Redundancy, Top- down and Bottom-up Approach, Volume of Information. Intelligent Manufacturing System Components, System Architecture and Data Flow, System Operation.

UNIT II KNOWLEDGE BASED SYSTEMS

L-9

Components of Knowledge Based Systems - Basic Components of Knowledge Based Systems, Knowledge Representation, Comparison of Knowledge Representation Schemes, Inference Engine, Knowledge Acquisition.

UNIT III ANN

L-9

Machine Learning - Concept of Artificial Intelligence, Conceptual Learning, Artificial Neural Networks - Biological Neuron, Artificial Neuron, Types of Neural Networks, Applications in Manufacturing.

UNIT IV MANUFACTURING SYSTEM DESIGN

L-9

Automated Process Planning - Variant Approach, Generative Approach, Expert Systems for Process Planning, Feature Recognition, Phases of Process planning. Knowledge Based System for Equipment Selection (KBSES) - Manufacturing system design. Equipment Selection Problem, Modeling the Manufacturing Equipment Selection Problem, Problem Solving approaches in KBSES, Structure of the KBSES.

UNIT V GROUP TECHNOLOGY

L-9

Group Technology: Models and Algorithms Visual Method, Coding Method, Cluster Analysis Method, Matrix Formation - Similarity Coefficient Method, Sorting-based Algorithms, Bond Energy Algorithm, Cost Based method, Cluster Identification Method, Extended CI Method. Knowledge Based Group Technology - Group Technology in Automated Manufacturing System. Structure of Knowledge based system for group technology (KBSCIT) — Data Base, Knowledge Base, Clustering Algorithm.

TOTAL: 45 PERIODS

8. Text Books

1. Intelligent Manufacturing Systems/ Andrew Kusiak/Prentice Hall.
2. Artificial Neural Networks/ Yagna Narayana/PHI/2006
3. Automation, Production Systems and CIM / Groover M.P./PHI/2007

9. References

1. Neural networks: A comprehensive foundation/ Simon Haykin/ PHI.
2. Artificial neural networks/ B.Vegnanarayana/PHI
3. Neural networks in Computer intelligence/ Li Min Fu/ TMH/2003
4. Neural networks/ James A Freeman David M S kapura/ Pearson education/2004
5. Introduction to Artificial Neural Systems/Jacek M. Zurada/JAICO Publishing House Ed. 2006.

COURSE CODE	MANUFACTURING SYSTEMS AND SIMULATION	L	T	P	C
10212ME166		3	0	0	3

1. Preamble

To highlight the basic concepts and procedure for simulation of manufacturing systems.

2. Pre-requisite

NIL

3. Link to the other courses

Project Work

4. Course Educational Objectives

Students, after undergoing this course would

- To understand the simulation and its types.
- To design various Design and evaluation of simulation experiments.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Explain the types, modelling, and applications of simulation in manufacturing system.	K2
CO2	Identify and apply suitable techniques for generation of random numbers in manufacturing systems	K3
CO3	Formulate, Design and validate simulation models for the given experiments.	K3
CO4	Select appropriate simulation languages for the given experiments by comparing different simulation languages.	K3
CO5	Design and develop discrete event model and network systems.	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M											M	
CO2	H	H	H	L								L	M	
CO3	H	H	H	L	L							L	M	L
CO4	H	H	M		L							L	M	L
CO5	H	H	H	L	L							L	L	L

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION

L-9

Systems – discrete and continuous systems, general systems theory, models of systems- variety of modeling approach, concept of simulation, simulation as a decision-making tool, types of simulation, Principle of computer modeling- Monte Carlo simulation, Nature of computer modeling, limitations of simulation, area of

application.

UNIT II RANDOM NUMBER GENERATION

L-9

Techniques for generating random numbers- mid square method, mid product method, constant multiplier technique, additive congruential method, linear congruential method. Tests for random numbers- Kolmogorov-Smirnov test, the Chi-square test.

UNIT III DESIGN AND EVALUATION OF SIMULATION L-9 EXPERIMENTS

Problem formulation, data collection and reduction, time flow mechanism, key variables, logic flow charts, starting condition, run size, experimental design consideration, output analysis, verification and validation of simulation models.

UNIT IV SIMULATION LANGUAGES

L-9

Comparison and selection of simulation languages, study of any one simulation language.

UNIT V DISCRETE EVENT SIMULATION

L-9

Concepts in discrete –event simulation, development of simulation models for queuing systems, production systems, inventory systems, maintenance and replacement systems, investment analysis and network.

TOTAL: 45 PERIODS

8. Text Books

1. Jerry Banks and John S Carson, Barry L Nelson, David M Nicol, "Discrete event system simulation", Prentice Hall, India, 2009.
2. Khoshnevi. B., "Discrete system simulation", McGraw Hill International edition, 1994
3. Ronald G Askin and Charles R Standridge, "Modeling and analysis of manufacturing systems", John Wiley & Sons, 1993.

9. References

1. Gordon G, "System Simulation", Prentice Hall, India, 1995.
2. Thomas J Schriber., "Simulation using GPSS", John Wiley & Sons, 1991.
3. Shannon, R.E., "System Simulation – The art and science", Prentice Hall, India, 1993.

COURSE CODE	MANUFACTURING INFORMATION	L	T	P	C
10212ME167	SYSTEMS	3	0	0	3

1. Preamble

This course provide an importance of databases and its application in manufacturing systems that prepare students for their engineering practice by organization by conversant with order policies, data base terminologies, designing, manufacturing considerations.

2. Pre-requisite

NIL

3. Link to the other courses

Project work.

4. Course Educational Objectives

Students, after undergoing this course would

- To understand the order policies of MRP to MRP II to ERP in manufacturing information system.
- To design data base model for information system using network approach.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describe the order policies of MRP to MRP II to ERP in manufacturing information system.	K2
CO2	Explain the data base model, technologies and ER diagram of information system	K2
CO3	Design the data base model for information system using network approach and relational operations.	K3
CO4	Explain scheduling module, Input/output, and IOM database for manufacturing considerations	K2
CO5	Develop Computerized manufacturing information system	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	H											H	
CO2	M	H											H	
CO3	M	H	H								L		H	
CO4	H	H											H	
CO5	M	H	M								L		H	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION

L-9

The Evolution of order policies from MRP to MRP II, Operations control, the role of

production organization.

UNIT II DATABASE CONCEPTS

L-9

Data modeling for a database, records and files, abstraction and data integration. Three level architecture for DBMS, Components of DBMS, Advantages and disadvantages of DBMS.

UNIT III DESIGNING DATABASE

L-9

Relationship among entities, ER diagram, Data Models: Relational, Network, Hierarchical. Relational Model – Concepts, principles, keys, Relational operations- Functional Dependency, Normalization, Query languages.

UNIT IV MANUFACTURING CONSIDERATION

L-9

The product and its structure, Inventory and process flow, Shop floor control, Data structure and procedure. Various models - The order scheduling module- Input/output analysis module- Stock status database- Complete IOM database.

UNIT V INFORMATION SYSTEM FOR MANUFACTURING

L-9

Computerized manufacturing information system- Case study.

TOTAL: 45 PERIODS

8. Text Books

1. C.J, "An Introduction to Database systems", Narosa Publishing House, 1997.
2. BipinC.Desai, "An Introduction to Database systems", west publishing Company, 1996.

9. References

1. Kerr. R, "Knowledge Based Manufacturing Management", Addison-Wesley, 1991.
2. Luca G. Sartori, "Manufacturing Information Systems", Addison-Wesley Publishing Company, 1988.

Theme 2: Computational Thermo Fluids

COURSE CODE	ADVANCED FLUID MECHANICS	L	T	P	C
10212ME168		2	1	0	3

1. Preamble

This course is a survey of principal concepts and methods of fluid dynamics. Topics include mass conservation, momentum, and energy equations for continua; Navier-Stokes equation for viscous flows; Similarity and dimensional analysis; lubrication theory; boundary layers and separation; circulation and vorticity theorems; potential flow; introduction to turbulence; lift and drag; surface tension and surface tension driven flows.

2. Pre-requisite

10210PH103-Applied Physics

10211ME208-Fluid Mechanics and Machinery

3. Link to the other courses

10212ME170-Computational Modeling of Multiphase and Reacting Flows

10212ME171-Modeling of Combustion and Emission Characteristics

4. Course Educational Objectives

Students, after undergoing this course would

- Possess the basic knowledge in fluid mechanics in the areas of applied engineering.
- Develop the skills in the areas of Compressible fluid flow and their effects.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Discuss the basic properties of fluids and solve typical fluid statics problems	K2
CO2	Develop the governing fluid dynamic equations and solve typical fluid dynamic problems	K2
CO3	Describe the boundary layer concepts and solve typical numerical problems	K3
CO4	Explain the Compressible fluid flow and solve typical numerical problems	K3
CO5	Express the Physical aspects of micro and nano flows	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	L		H		L	H	H	L	H			M	L
CO2	H	M		H		L	H	H	L	H			M	L
CO3	H			H		L	H	H	L	H			M	L
CO4	H	M		H		L	H	H	L	H			M	L
CO5	H			H		L	H	H	L	H			M	L

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I CONCEPTS OF FLUIDS

L-6 T-3

Definitions of fluids- concept of continuum- different types of fluid, tensor analysis- governing laws of fluid mechanics in integral form- Reynold's transport theorem- mass, momentum and energy equations in integral form and their applications- continuity equation.

UNIT II INVISCID FLOW OF INCOMPRESSIBLE FLUIDS:

L-6 T-3

The stream function- The stream function in Cartesian coordinates- The stream function in cylindrical coordinates- The differential linear momentum equation – Cauchy's equation- The Navier-Stoke's equation- Derivation of Navier-Stoke's equation for incompressible- isothermal flow- Differential analysis of fluid flow problems.

UNIT III BOUNDARY LAYER CONCEPTS

L-6 T-3

The boundary layer equations- Displacement thickness. Momentum thickness- Turbulent flat plate boundary layer- Boundary layers with pressure gradients- Drag and lift- Friction and pressure drag- Drag coefficients of common geometries- Parallel flow over flat plates- Flow over cylinders and spheres- Lift.

UNIT IV COMPRESSIBLE FLUID FLOW

L-6 T-3

Compressible Flow- Stagnation properties- One dimensional isentropic flow- Isentropic flow through nozzles- Shock waves and expansion waves- Duct flow with heat transfer and negligible friction (Rayleigh flow)- Adiabatic duct flow with friction.

UNIT V MICRO AND NANO FLOW

L-6 T-3

Physical aspects of micro and nano flows- governing equations- surface tension driven flows- modeling of micro and nano flows.

TOTAL: 30+15=45 PERIODS

8. Text Books

1. Fox and McDonald – 'Fluid Mechanics' – John Wiley – 2011 – 8th Edition
2. White F.M. – 'Fluid Mechanics' – McGraw Hill International Edition, 2010, 7th Ed.

9. References

1. Panton R. L. – 'Incompressible Flow' – Wiley India, 2013 – 4th Edition
2. Cengel Y. A. and Cimbala J. M. – 'Fluid Mechanics (Fundamentals and Applications)' – The McGraw Hill, India – 2013 – 3rd Edition
3. Fluid Mechanics: by Pijush K. Kundu, Ira M. Cohen, David R Dowling, Academic Press
4. Introduction to Fluid Mechanics and Fluid Machines: by S. K. Som, Gautam Biswas and Suman Chakraborty, McGraw-Hill Education
5. Shames I. H., Mechanics of Fluids, Tata McGraw Hill, Delhi, 4th edition 2003.
6. Douglas and Swaffield, Fluid Mechanics, Prentice Hall, 5th edition 2006.
7. Yahya S. M., Fundamentals of Compressible Flow, Tata McGraw Hill, Delhi, 3rd edition 2003.

COURSE CODE	COMPUTATIONAL HEAT TRANSFER AND	L	T	P	C
10212ME169	FLUID FLOW	3	0	0	3

1. Preamble

This course is a survey of the basic ideas underpinning large-eddy simulation (LES) and direct numerical simulation (DNS). These resource-intensive turbulence prediction techniques are likely to have a major impact in the medium term on CFD due to the increased availability of high-end computing capability. Application of CFD results in industrial research and design crucially hinges on confidence in its outcomes.

2. Pre-requisite

10211ME208-Fluid Mechanics and Machinery

3. Link to the other courses

10212ME170-Computational Modeling of Multiphase and Reacting Flows

10212ME171-Modeling of Combustion and Emission Characteristics

4. Course Educational Objectives

Students, after undergoing this course would

- Possess the knowledge in Computational Fluid mechanics.
- Develop the skills in the areas of Generate grid, time dependant methods their effects in the computational solution.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Apply suitable discretization methods for numerical evaluation of heat transfer and fluid flow problems	K3
CO2	Solve 1D,2D and 3D steady and non-steady conduction and convection problems	K3
CO3	Apply governing equations and partial differential equations to predict the mathematical behavior of turbulent flow	K3
CO4	Apply structured and unstructured grid generation techniques to divide the volume of the given 2D and 3D geometries	K3
CO5	Apply implicit and explicit time dependent methods to solve heat transfer problems	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	H	M	L								H	H
CO2	H	H	H	M	L								H	H
CO3	H	H	H	M	L								H	H
CO4	H	H	H	M	L								H	H
CO5	H	H	H	M	L								H	H

(HL- High; M-Medium; L-Low)

7. Course Content

UNIT I DISCRETIZATION METHODS

L-9

The Nature of Numerical Methods- The Task-The Discretization Concept- The Structure of the Discretization Equation- Methods- Taylor series Formulation_ Variational Formulation-Weighted Residuals- Control volume formulation.

UNIT II HEAT TRANSFER ANALYSIS

L-9

Steady one – dimensional conduction- The grid spacing- the interface conductivity- Unsteady one dimensional conduction- Explicit, crank Nicolson- Fully Implicit- Discretization equation for Two Dimensions- Discretization equation for Three Dimensions- steady one dimensional convection- the upwind scheme- the exact solution- the Exponential scheme.

UNIT III FLOW FIELD ANALYSIS

L-9

Basics of computational fluid dynamics – Governing equations– Continuity, Momentum and Energy equations – Chemical species transport –Physical boundary conditions – Time-averaged equations for Turbulent Flow – Turbulent–Kinetic Energy Equations – Mathematical behaviour of PDEs on CFD - Elliptic, Parabolic and Hyperbolic equations.

UNIT IV GRID GENERATION

L-9

Introduction to grid generation in computational fluid dynamics - Structured grid generation techniques – algebraic methods, conformal mapping and methods using partial differential equations - Boundary value problem of numerical grid generation- grid control functions- branch cut - The boundary conditions of first kind - orthogonality of grid lines- boundary point grid control. Unstructured grids, Cartesian grids, hybrid grids, grids around typical 2D and 3D geometries.

UNIT V TIME DEPENDENT METHODS

L-9

Introduction to time dependent methods - Explicit time dependent methods – Description of LaxWendroff Scheme and Mac Cormack's two step predictor – corrector method - Description of time split methods. Introduction to implicit methods and respective stability properties of explicit and implicit methods - Construction of implicit methods for time dependent problems - Linearization, choice of explicit operator and numerical dissipation aspects.

TOTAL: 45 PERIODS

8. Text Books

1. Fletcher C.A.J., "Computational Techniques for Fluid Dynamics 2", Springer Verlag, 1995
2. Versteeg, H.K., and Malalasekera, W., "An Introduction to Computational Fluid Dynamics": The finite volume Method, Pearson
3. Suhas V, Patankar, "Numerical Heat transfer and Fluid flow", Taylor & Francis, 2009.

9. References

1. Chung T. J., "Computational Fluid Dynamics", Cambridge University Press; 2nd edition, 2010.
2. Hirsch C., "Numerical Computation of Internal and External Flows" Volume-2,

John Wiley and Sons, 1994.

3. Joel H. Ferziger & Milovan Peric, "Computational Methods for Fluid Dynamics" Springer; 3rd edition 2002.
4. John F Wendt , "Computational Fluid Dynamics – An Introduction", 3rd Edition, SpringerVerlag, Berlin Heidelberg, 2009.

COURSE CODE	COMPUTATIONAL MODELING OF MULTI	L	T	P	C
10212ME170	PHASE AND REACTING FLOWS	3	0	0	3

1. Preamble

This course describes in detail about Multiphase flow reactors. The performances of these reactors largely depend on the interactions of different phases involved. In this course, basic of Multiphase flow along with different flow regime map and pressure drop, and volume fraction calculation will be covered. Modeling methods used for multiphase flow reactors will be covered.

2. Pre-requisite

10211ME208-Fluid Mechanics and Machinery

10212ME169-Computational Heat Transfer and Fluid Flow

3. Link to the other courses

10212ME172-Decision Making in Large Scale Systems

4. Course Educational Objectives

Students, after undergoing this course would

- Possess the basic knowledge in Multiphase flow reactors, Particle Flows
- Develop the skills in the areas of turbulent reacting flows, Statistical description of turbulent flow and Mixing

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Apply Eulerian and Lagrangian frameworks to determine the multi-phase of the given continuum model	K3
CO2	Apply elimination algorithm methods to solve multi-phase flow problems	K3
CO3	Develop numerical models to solve gas and liquid particle flow problems	K3
CO4	Develop numerical models to solve turbulent reacting flows problems	K3
CO5	Show the statistical description of turbulent flow and Phenomenology of turbulent mixing in engineering models.	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	H									L	H	
CO2	H	H	H									L	H	
CO3	H	H	H	L								L	H	L
CO4	H	H	H	L								L	H	L
CO5	H	H	H										H	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I GOVERNING EQUATIONS AND BOUNDARY CONDITIONS L-9

Eulerian–Eulerian interpenetrating continua and Eulerian–Lagrangian frameworks for multiphase calculations- phase indicator function and averaging being performed in time, space-the effective conservation equations - the interfacial sources - the mixture or homogeneous model and two-fluid or multifluid model.

UNIT II METHODS FOR MULTI-PHASE FLOWS L-9

Computational solutions stages- mesh generation - numerical discretization - Extensive derivation - specific numerical techniques to solve the discretized equations. - standard techniques developed for single-phase flows, -multiphase flows- the Elimination Algorithm - Non-linearly Coupled Equations -Phase Slip Algorithm - Inter-Phase Slip Algorithm-Coupled, Method Pressure-Linkage Equations pressure –velocity coupling scheme, and a coupled solver approach interface tracking/capturing methods.

UNIT III PARTICLE FLOWS L-9

Gas-particle flows: natural and technological systems-environmental particle pollution- predict the dispersion natural flow phenomena of dispersing particle pollutants- providing effective solutions in reducing the high concentrations - acceptable concentration levels. Liquid–Particle Flows: homogeneous mixture-the model equations - the flocculation process of the activated sludge, the population balance approach, the mixture model an algebraic slip model heterogeneous mixture.

UNIT IV TURBULENT REACTING FLOWS L-9

Introduction to Laminar and Turbulent reacting flows, Chemical-reaction-engineering approach- PFR and CSTR models - RTD theory - Zone models - Micromixing models - Micromixing time - Fluid-mechanical approach - Fundamental transport equations - Turbulence models - Chemical source term - Molecular mixing.

UNIT V STATISTICAL DESCRIPTION OF TURBULENT FLOW AND MIXING L-9

Turbulent flow: Homogeneous turbulence- One-point probability density function- Spatial correlation functions- Temporal correlation functions- Turbulent energy spectrum- Inhomogeneous turbulence - Expected values of derivatives- Mean velocity- Turbulent dissipation rate

Turbulent mixing: Phenomenology of turbulent mixing -Homogeneous turbulent mixing – Inhomogeneous turbulent mixing -Differential diffusion.

TOTAL: 45 PERIODS

8. Text Books

1. Guan Heng Yeoh, Jiyuan Tu, “Computational Techniques for Multiphase Flows” Elsevier, 2017
2. S. Hernández, P. Vorobieff, “Multiphase Flow “ , WIT Press, 2020

9. References

1. Andrea Prosperetti, Grétar Tryggvason, “Computational Methods for Multiphase

- Flow", Cambridge University Press,2009
2. Bipin Kumar, "Computational Techniques for Multiphase Fluid Flows", LAP Lambert Academic Publishing, 2013
 3. Chao Zhu,Liang-Shih Fan,Zhao Yu , "Dynamics of Multiphase Flows", Cambridge University Press,2021
 4. Zhangxin Chen,Guanren Huan,Yuanle Ma , "Computational Methods for Multiphase Flows in Porous Media" Society for Industrial and Applied Mathematics,2006.

COURSE CODE	MODELING OF COMBUSTION AND EMISSION CHARACTERISTICS	L	T	P	C
10212ME171		3	0	0	3

1. Preamble

This course is a survey of principal concepts and methods of Turbulent Combustion computations. Topics include Turbulent Premixed and Non Premixed combustion for continua; Probability Density Function Methods for combustion; Emission Characteristics.

2. Pre-requisite

10211ME208-Fluid Mechanics and Machinery

10212ME169-Computational Heat Transfer and Fluid Flow

3. Link to the other courses

10212ME172-Decision Making in Large Scale Systems

4. Course Educational Objectives

Students, after undergoing this course would

- Possess the basic knowledge in Turbulent Combustion computations in the areas of applied engineering.
- Develop the skills in the areas of Probability Density Function Methods and their effects and in the concept of Modelling Turbulent combustion.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Apply direct numerical simulation and diagnostics techniques in turbulent combustion science	K3
CO2	Apply direct numerical simulation methods to model premixed and non-premixed combustion	K3
CO3	Apply probability density function methods to model the engine combustion	K3
CO4	Apply turbulent combustion techniques to analyze the characteristics of combustion and flames	K3
CO5	Outline the emission formation, characteristics, and control methods employed in SI and CI engines	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	H	M	M		H						H	M
CO2	H	H	H	M	H		H					M	H	M
CO3	H	H	H	M	H		H					M	H	M
CO4	H	H	H	M	H		H					M	H	M
CO5	H	H	H				H						H	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I TURBULENT COMBUSTION COMPUTATIONS L-9

Mechanics and modelling of turbulence – combustion interaction- kinetics in combustion simulation: Manifestation, Model Reduction – Computational Diagnostics- high performance computing- Direct Numerical simulation for combustion science.

UNIT II TURBULENT PREMIXED AND NON PREMIXED COMBUSTION L-9

Turbulent Premixed combustion: Direct Numerical simulations – RANS simulations of premixed Turbulent flames- Modeling using Flame let- Generated Manifolds- conditional moment closure

Non Premixed combustion: Direct Numerical simulations of auto ignition- soot predictions – Modelling of soot formation in a spray flame

UNIT III PROBABILITY DENSITY FUNCTION METHODS L-9

Transported PDF method for Mild combustion- Large – Eddy simulation of Nonpremixed flames by explicit filtering- Theory and application of Multiple mapping conditioning for Turbulent Reactive flows.

UNIT IV MODELING TURBULENT COMBUSTION L-9

Combustion modeling of spray flames using flamelet models- Numerical simulation of Turbulent in internal combustion engines- characterization of turbulent combustion system using dynamical systems theory- Theory and modelling of flame acceleration and deflagration to Detonation Transition- Combustion simulation in supersonic flows and scramjet.

UNIT V EMISSION CHARACTERISTICS L-9

Measurement of emissions- instrumentation for CO HC, NO_x, PM- Strategies for control of emissions in SI engines; Add on systems to control emissions inside the engine: EGR, crankcase and evaporative emission control- Exhaust gas after treatment, Thermal and catalytic reactors, Elements of catalytic reactors, catalysts and substrates- Oxidation, reduction and 3-way catalytic reactors, closed loop feedback control, catalyst deactivation mechanism, cold start HC control- Petroleum fuels : impact of fuel characteristics including oxygenates on emissions- Alternative fuels to reduce emissions: Alcohols, natural gas, biodiesel, hydrogen, DME.

TOTAL: 45 PERIODS

8. Text Books

1. Kenneth K. Kuo , “Principles of Combustion Paperback” Liley India Pvt Ltd; Second edition ,2012
2. Andrei Lipatnikov, “Numerical Simulations of Turbulent Combustion”, Mdpi AG, 2020.

9. References

1. Gunter P. Merker, Christian Schwarz, Gunnar Stiesch, Frank Ott Simulating, “Combustion: Simulation of combustion and pollutant formation for engine-development” Springer , 2005
2. Huang Chen, “Combustion Modelling” LAP Lambert Academic Publishing, 2010.

COURSE CODE	DECISION MAKING IN LARGE SCALE SYSTEMS	L	T	P	C
10212ME172		3	0	0	3

1. Preamble

This course is an introduction to the theory and application of large-scale dynamic programming. Topics include Markov decision processes, dynamic programming algorithms, simulation-based algorithms, theory and algorithms for value function approximation, and policy search methods. The course examines games and applications in areas such as dynamic resource allocation, finance and queueing networks.

2. Pre-requisite

10211ME208-Fluid Mechanics and Machinery

10212ME169-Computational Heat Transfer and Fluid Flow

3. Link to the other courses

10212ME205-Computational Analysis of Thermo fluid Capstone

4. Course Educational Objectives

Students, after undergoing this course would

- Possess the knowledge in field of Decision Processes
- Develop the skills in the areas of Policy Search Methods and Game Theory to the design of large scale systems.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Apply the Markov decision processes in Finite-Horizon and Discounted-Cost application to minimize the cost	K3
CO2	Formulate and Apply simulation based algorithms to the given queuing network applications	K3
CO3	Estimate the true value function of the given condition using value function approximation algorithms for decision making applications	K3
CO4	Develop a decision making model for a helicopter control using policy search algorithms	K3
CO5	Develop a mathematical model for the given application using GAME theory	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

[illegible]

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I DECISION PROCESSES

L-9

Markov Decision Processes- Finite-Horizon Problems: Backwards Induction- Discounted-Cost Problems: Cost-to-Go Function, Bellman's Equation- Value Iteration- Existence and Uniqueness of Bellman's Equation Solution- Gauss-Seidel Value Iteration -Optimality of Policies derived from the Cost-to-Go Function- Policy Iteration- Asynchronous Policy Iteration- Average-Cost Problems- Relationship with Discounted-Cost Problems- Bellman's Equation- Blackwell Optimality- Average-Cost Problems.

UNIT II SIMULATION-BASED METHODS

L-9

Computational Methods- Application of Value Iteration to Optimization of Multiclass Queueing Networks- Introduction to Simulation-based Methods Real-Time Value Iteration- Q-Learning- Stochastic Approximations- Stochastic Approximations: Lyapunov Function Analysis- The ODE Method- Convergence of Q-Learning- Exploration versus Exploitation: The Complexity of Reinforcement Learning.

UNIT III VALUE FUNCTION APPROXIMATION

L-9

Introduction to Value Function Approximation- Curse of Dimensionality- Approximation Architectures- Model Selection and Complexity- Introduction to Value Function Approximation Algorithms- Performance Bounds - Temporal-Difference Learning with Value Function Approximation- Optimal Stopping Problems - General Control Problems- Approximate Linear Programming- Efficient Solutions for Approximate Linear Programming- Efficient Solutions for Approximate Linear Programming: Factored MDPs.

UNIT IV POLICY SEARCH METHODS

L-9

Policy Search Methods for POMDPs- Application: Call Admission Control- Actor-Critic Methods-Approximate POMDP Compression- Policy Search Methods: PEGASUS- Application: Helicopter Control- Complexity of Policy Search.

UNIT V GAME THEORY

L-9

Introduction, overview, uses of game theory- normal form, payoffs, strategies, pure strategy Nash equilibrium, dominant strategies Mixed-Strategy Nash Equilibrium- Iterative removal of strictly dominated strategies, minimax strategies and the minimax theorem for zero-sum game, correlated equilibria Extensive-Form Games- Perfect information games: trees, players assigned to nodes, payoffs, backward Induction, subgame perfect equilibrium, introduction to imperfect-information games.

TOTAL: 45 PERIODS

8. Text Books

1. Bertsekas, Dimitri P. Dynamic Programming and Optimal Control. 2 vols. Belmont, MA: Athena Scientific, 2007. ISBN: 9781886529083.

9. References

1. Data-Driven Science and Engineering: Machine Learning, Dynamical Systems,

and Control Steven L. Brunton

2. Deep Learning (Adaptive Computation and Machine Learning series) Ian Goodfellow
3. Reinforcement Learning – An Introduction (Adaptive Computation and Machine Learning series) Richard S. Sutton
4. Bertsekas, Dimitri P., and John N. Tsitsiklis. Neuro-Dynamic Programming. Belmont, MA: Athena Scientific, 1996. ISBN: 9781886529106.
5. Reinforcement Learning and Optimal Control by Dimitri Bertsekas | 15 July 2019.

COURSE CODE	DESIGN AND OPTIMIZATION OF THERMO FLUID SYSTEMS	L	T	P	C
10212ME173		3	0	0	3

1. Preamble

Most of the systems we encounter in our life have energy transfer in various forms. One needs to design these equipment's/devices to consume minimum output. There are other factors such as cost and reliability that also need to be considered. Optimization helps to design the equipment's by taking all these parameters into account. The objective of this course is to perform analysis of all the parameters and their effect on the performance of equipment's and select the optimum conditions.

2. Pre-requisite

10211ME208-Fluid Mechanics and Machinery

10212ME169-Computational Heat Transfer and Fluid Flow

3. Link to the other courses

10212ME205-Computational Analysis of Thermo fluid Capstone

4. Course Educational Objectives

Students, after undergoing this course would

- Possess the knowledge in design process, mathematical models and simulation
- Develop the skills in the areas of objective function and search methods

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Illustrate the selection procedure and types of thermo economic heat exchanger	K3
CO2	Illustrate the types valves used in thermofluid devices and analyze the losses in the piping network	K3
CO3	Develop the analog, mathematical, and numerical model for thermofluid simulation using Matrix methods	K3
CO4	Use calculus approach to formulate a model for thermofluid optimization	K3
CO5	Apply search algorithms for geometric programming of thermofluid systems	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H											H	
CO2	H	H	M										H	
CO3	H	H	M										H	
CO4	H	H	M										H	
CO5	H	H	M										H	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION

L-9

Development, Design, and Analysis - The Design Process - Engineering Economics - Present Worth Factor - Money Flow Series - Cash Flow Diagram - Thermo-economics- Heat Exchangers: Types of Heat Exchangers -Indirect-Contact Heat Exchangers -A Single Fluid in a Conduit of Constant Temperature -Heat Transfer from a Hot Stream to a Cold Stream - Log Mean Temperature Difference -Correction Factor - Comments on Heat Exchanger Selection.

UNIT II THERMOFLUID DEVICES

L-9

Valves: Ball Valves - Butterfly Valves - Gate Valves -Globe Valves - Needle Valves - Pinch Valves -Plug Valves -Poppet Valves - Saddle Valves - Ducts, Pipes, and Fittings - Laminar and Turbulent Flow - Entrance to Fully Developed Pipe Flow- Friction of Fully-Developed Pipe Flow - Head Loss along a Pipe Section -Piping Network.

UNIT III MODEL VERSUS SIMULATION

L-9

Types of Models - Analog Models -Mathematical Models -Numerical Models -Physical Models-Forms of Mathematical Models -Curve Fitting -Least Error Linear Fits - Least Error Polynomial Fits - Non-Polynomial into Polynomial Functions -Multiple Independent Variables Thermofluid System Simulation- Information-Flow Diagram - Solving a Set of Equations via the Matrix Approach -Sequential versus Simultaneous Calculations -Successive Substitution -Taylor Series Expansion and the Newton-Raphson Method - Taylor Series Expansion -The Newton-Raphson Method.

UNIT IV OPTIMIZATION

L-9

Objective Function and Constraints - Formulating a Problem to Optimize -Calculus Approach - Lagrange Multiplier -Unconstrained, Multi-Variable, Objective Function - Multi-Variable Objective Function with Equality Constraints -Significance of the Lagrange Multiplier Operation -The Lagrange Multiplier as a Sensitivity Coefficient - Dealing with Inequality Constraints.

UNIT V SEARCH METHODS

L-9

Elimination Methods -Exhaustive Search -Dichotomous Search -Fibonacci Search - Golden Section Search -Comparison of Elimination Methods -Multi-variable, Unconstrained Optimization -Exhaustive Search -Lattice Search -Univariate Search - Steepest Ascent/Descent Method - Multi-variable, Constrained Optimization - Penalty Function Method- Geometric Programming -Common Types of Programming -Single-Variable, Unconstrained Geometric Programming - Multi-Variable, Unconstrained Geometric Programming -Constrained Multi-Variable Geometric Programming.

TOTAL: 45 PERIODS

8. Text Books

1. Design and optimization of thermal systems, Y.Jaluria, McGraw Hill, 1998.

9. References

1. Thermal Design and Optimization, Adrian Bejan, George Tsatsaronis, Michael Moran, John Wiley and Sons, 1995.
2. Elements of thermal fluid system design, L.C. Burmeister, Prentice Hall, 1998.
Design of thermal systems, W.F.Stoecker, McGraw Hill, 1989.

CO3	H	H	M										H	
CO4	H	H	M										H	
CO5	H	H	M										H	
CO6	H	H	H	M	H					M		M	H	H

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I CFD ANALYSIS- THE SOFTWARE PERSPECTIVE

L-9 P-6

Introduction to commercial CFD software- Basic steps – process- Geometry creation- user interface.

UNIT II MESHING

L-9 P-6

Fundamental concepts of meshing- Hexahedral meshing- shell meshing- volume meshing process- Tetrahedral meshing- prism meshing.

UNIT III SIMULATION

L-9 P-6

Solver basics-Turbulence modeling- Boundary and cell zone conditions- solver mathematics and post processing.

UNIT IV MODELLING OF HEAT TRANSFER AND FLUID FLOW

L-9 P-6

Conduction- convective- Radiation- solar load model- Multiphase flows- volume of Fluid (VOF) model- Discrete phase model (DPM)- Mixture Model- wet stream model.

UNIT V TURBO MACHINERY FLOWS

L-9 P-6

Rotating Machinery flows- single Rotating Reference Frame (SRF) Model- Multiple Moving Reference Frame Model- Sliding and Moving Mesh models.

7.LIST OF EXPERIMENTS:

1. Mesh Generation 2D profile geometry
2. Meshing generation for Heat exchanger geometry
3. Mesh generation for catalytic convertor geometry
4. Heat transfer around array of heated cylinders
5. Solar load model
6. Modeling multiphase flow through channel
7. Modeling flow of granular solid particles along a fluid stream
8. Modeling particle flow in a duct system
9. Flow in a stirred tank without baffles
10. Flow in a centrifugal blower
11. CFD modeling of turbulent flow through nozzle geometry

TOTAL: 75 PERIODS

8. Text Books

1. Fletcher C.A.J., "Computational Techniques for Fluid Dynamics 2", Springer Verlag, 1995
2. Versteeg, H.K., and Malalasekera, W., "An Introduction to Computational Fluid Dynamics": The finite volume Method, Pearson

9. References

1. Chung T. J., "Computational Fluid Dynamics", Cambridge University Press; 2nd edition, 2010.
2. Hirsch C., "Numerical Computation of Internal and External Flows" Volume-2, John Wiley and Sons, 1994.
3. Joel H. Ferziger & Milovan Peric, "Computational Methods for Fluid Dynamics" Springer; 3rd edition 2002.
4. John F Wendt , "Computational Fluid Dynamics – An Introduction", 3rd Edition, Springer Verlag, Berlin Heidelberg, 2009.

B.Tech. WITH MINOR SPECIALIZATION**Theme 1: Smart Manufacturing**

COURSE CODE	COMPUTER AIDED PRODUCT DESIGN	L	T	P	C
10213ME202		2	0	2	3

1. Preamble

The course aims at introducing the students to the basic concepts of engineering design and product development with focus on the front end processes.

2. Pre-requisite

NIL

3. Link to the other courses

10213ME102-Integrated Product Development

4. Course Educational Objectives

Students, after undergoing this course would

- To demonstrate and understand the overview of product development processes.
- To reinforces the knowledge being learned and shortens the overall learning curve which is necessary to solve CAE problems that arise in engineering.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describe the phases and societal consideration for product development	K2
CO2	Develop 1D, 2D and special curves using Bezier, B-Spline and NURBS equations	K3
CO3	Apply B-rep and C-rep methods to develop solid modeling for product design	K3
CO4	Develop geometric layout and architecture for product development	K3
CO5	Write CNC codes for the given component for product design and development	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M											
CO2	H	H										
CO3	H	H	M			M						
CO4	H	H	M			M						
CO5	H	H	M			M						

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION

L-6 P-6

Need for Developing Product – Importance of Engineering Design – Types of Design – Design Process – Relevance of Product lifecycle issue in Design – Various Phases of Product Development – Societal Consideration in Engineering Design.

Experiments: Introduction to AutoCad, Basic comments like Line, Circle, Rectangle.

UNIT II COMPUTER GRAPHICS FUNDAMENTALS

L-6 P-6

Computer graphics – applications – principals of interactive computer graphics – 2D, 3D transformations – projections – curves – Bezier, B-Spline and NURBS – Concepts.

Experiments: Simple 2D Diagrams using Extrude, Trim, Sweep, Mesh of curves, Free form.

UNIT III OPTIMIZATION: FUNDAMENTALS

L-6 P-6

Geometric Modeling – types – Wire frame, surface and solid modeling – Boundary Representation, constructive solid geometry – Graphics standards – assembly modelling.

Experiments: Simple Isometric drawings

UNIT IV PRODUCT ARCHITECTURE

L-6 P-6

Product Development Management - Establishing the Architecture - Creation - Clustering - Geometric Layout Development - Fundamental and Incidental Interactions - Related System Level Design Issues - Secondary Systems.

Experiments: Simple Layout creation for the 3D model

UNIT V INDUSTRIAL DESIGN

L-6 P-6

Integrate Process Design - Managing Costs - Robust Design - Integrating CAE, CAD, CAM tools – Simulating Product Performance and Manufacturing Processes Electronically - Need for Industrial Design - Impact - Assessing the Quality of Industrial Design.

Experiments: Generate CNC code and conversion of IGES, STTP formats

TOTAL: 60 PERIODS

8. Text Books

1. Anita Goyal, Karl T Ulrich, Steven D Eppinger, “Product Design and Development“, 4th Edition, 2009, Tata McGraw-Hill Education, ISBN-10-007-14679-9.
2. Ibrahim Zeid, CAD/CAM theory and Practice, Tata McGraw Hill, 1991.
3. Clive L.Dym, Patrick Little, “Engineering Design: A Project-based Introduction“, 3rd Edition, John Wiley & Sons, 2009, ISBN 978-0-470-22596-7.
4. Product Design and Development, Karl T.Ulrich and Steven D.Eppinger, McGraw –Hill International Edns.1999.

9. References

1. Concurrent Engg./Integrated Product Development. Kemnneth Crow, DRM Associates, 6/3,ViaOlivera, Palos Verdes, CA 90274(310) 377-569,Workshop

Book.

2. Effective Product Design and Development, Stephen Rosenthal, Business One Orwin, Homewood, 1992, ISBN, 1-55623-603-4.
3. Foley, Wan Dam, Feiner and Hughes – Computer graphics principles & practices, Pearson Education – 2003.
4. Ibrahim Zeid Mastering CAD/CAM – McGraw Hill, International Edition, 2007.

COURSE CODE	FINITE ELEMENT ANALYSIS USING ANSYS	L	T	P	C
10213ME203		2	0	2	3

1. Preamble

This course imparts the knowledge to develop a thorough understanding of the basic principles of the finite element analysis techniques with an ability to effectively use the tools of the analysis for solving practical problems arising in engineering applications.

2. Pre-requisite

NIL

3. Link to the other courses

NIL

4. Course Educational Objectives

Students, after undergoing this course would

- Understand how to mathematically model physical systems and solve using numerical techniques.
- Select appropriate element and boundary conditions for various 1D & 2D Boundary value problems.
- Give exposure to software tools needed to analyses engineering problems.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Develop mathematical modelling for field problems using governing equations, Eigen, and weighted residual method	K3
CO2	Develop stiffness matrices for 1D problems and perform stress and deflection analysis (bars and beams) using FEA tool.	K3
CO3	Develop stiffness matrices for 2D problems and perform stress analysis on axi-symmetric components using FEA tool.	K3
CO4	Develop the finite element formulations for heat transfer problems and demonstrate heat transfer analysis for the given 2D problems	K3
CO5	Solve analytically the vibrational problems and demonstrate model analysis on bars and beams	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	M		M					L		
CO2	H	H	M	L	M					L		M
CO3	H	H	M	L	M					L		M
CO4	H	H	M	L	M					L		M
CO5	H	H	M	L	M					L		M

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION

L-6 P-6

Historical Background – General steps in FEA - Mathematical Modelling of field problems in Engineering, Governing Equations, Boundary, Initial and Eigen Value problems, Weighted Residual Methods.

Experiments: Demonstration on Ansys Working Environment, Creations of Key points, Lines, Surfaces.

UNIT II ONE-DIMENSIONAL PROBLEMS

L-6 P-6

One Dimensional Second Order Equations, Discretization, Element types Linear and Higher order Elements, Derivation of Shape functions and Stiffness matrices - Bar Element Problems

Experiments: Stress and Deflection Analysis of Bar & Beam with Different Support Conditions.

UNIT III TWO DIMENSIONAL PROBLEMS

L-6 P-6

Second Order 2D Equations involving Scalar Variable Functions – Derivation of Shape functions and Stiffness matrices of CST element – Triangular Element Problems.

Experiments: Stress analysis of axi-symmetric components, Analysis of Chimney.

UNIT IV HEAT TRANSFER PROBLEMS

L-6 P-6

Derivation of Shape functions and Stiffness matrices of 1D Heat Conduction - 1D Heat Conduction Problems.

Experiments: Transient Heat Transfer Analysis and Thermal Analysis of 2D Heat Sink.

UNIT V DYNAMIC ANALYSIS USING FEA

L-6 P-6

Introduction – Vibrational Problems –Longitudinal Vibration of Bars – Transverse Vibration of Beams.

Experiments: Modal Analysis of Bar & Beam.

TOTAL: 60 PERIODS

8. Text Books

1. David V.Hutton, "Fundamentals of Finite Element Analysis", Tata McGraw-Hill Edition, 2005.
2. T.R. Chandrupatla, A.D. Belegundu, "Introduction to finite elements in engineering", PrenticeHall.

9. References

1. M.S. Gadala, "Finite Elements for Engineers with Ansys Applications", Cambridge University Press.
2. T.J.R. Hughes, "The Finite Element Method: Linear Static and Dynamic Finite Element Analysis", Dover Publications.
3. J.N. Reddy, "An Introduction to the Finite Element Method", McGraw-Hill Education.

COURSE CODE	MANUFACTURING SIMULATION USING	L	T	P	C
10213ME204	CNC CODES	2	0	2	3

1. Preamble

This course will cover fundamental concepts of CNC codes and advanced tool techniques. It will endow students with abilities in CNC machine, program and Manufacturing based solutions for real-world and engineering problems.

2. Pre-requisite

NIL

3. Link to the other courses

NIL

4. Course Educational Objectives

Students, after undergoing this course would

- To identify and describe advanced tool techniques and their roles in mechanical components.
- To recognize the feasibility of applying a unigraphics software for the particular problem.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Compare the conventional and numerical control technology used in part manufacturing	K3
CO2	Interpret and Write a CNC part programming for the given drawings/components using G and M codes to manufacture the part	K3
CO3	Develop a numerical control part program to machine the surfaces of the given drawing using CAE tool	K3
CO4	Distinguish between CNC and DNC machine tools and develop 3D model using CAD tools	K3
CO5	Interpret the codes, standards and data exchanges formats used in CNS part programming	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	M										
CO2	H	H	H		H							
CO3	H	H	M		H							
CO4	H	M										
CO5	H	H	M		H							

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION

L-6 P-6

Need of NC technology, Fundamental concepts in numeric control: structure and functions of NC System, advantages of NC technology over conventional manufacturing.

Experiments: Exercises in tool presetting and workpiece referencing on CNC machine tools.

UNIT II NC MACHINE TOOLS

L-6 P-6

Work holding and tool setting procedure for NC turning and milling centres, Tool zero presetting, Block formats and introduction to ISO based G & M codes for NC part programming, Concepts of tool length and radius compensation, Standard canned cycles used in CNC turning and milling centres.

Experiments: manual part programming for CNC turning and milling centres.

UNIT III CNC MACHINE TOOLS

L-6 P-6

Introduction to automatic NC part program generation from CAD models using standard CAD/CAM software for machining of surfaces, moulds and dies etc.

Experiments: Use of software for simulation of turned and milled parts and simple surfaces, Automatic Cutter location data generation from CAD Models in APT format

UNIT IV TYPES AND FUNCTIONS OF CNC & DNC

L-6 P-6

Introduction - Types and functions of computer numeric control (CNC), Types and functions of direct numeric control (DNC),

Experiments: To produce an industrial component by interpreting 3D part model/ part drawings using Computer Aided Manufacturing technology through programming, setup based on Computer Numerical Control (CNC) machine tools.

UNIT V CAD DATA AND PROGRAMMING TECHNIQUES

L-6 P-6

Transformations, Solid modeling for RP, Surface modeling, STL file generation, Defects in STL files and repairing algorithms, Interface formats, Slicing methods, Design of support structures, Internal hatching and surface skin fills

Experiments: programming techniques, applications, merits and demerits of Computer Numerical Controlled (CNC) machines.

TOTAL: 60 PERIODS

8. Text Books

1. NX 10 for Engineering Design, Ming C. Leu, Missouri University Of Science And Technology.
2. Koren, Y., Computer Control of Manufacturing systems, McGraw Hill (2009).

9. References

1. Chris McMahon and Jimmie Browne "CAD/CAM Principles, practice and manufacturing management "Pearson education Asia, 2001.
 2. Smith Peter, CNC programming handbook, 2nd edition, 2003, Industrial Press Inc.
-

COURSE CODE	PRACTICAL ASPECTS IN ADDITIVE MANUFACTURING	L	T	P	C
10213ME117		3	0	0	3

1. Preamble

The objective of the course is to impart fundamentals of additive manufacturing processes along with the various file formats, software tools, processes, techniques and applications.

2. Pre-requisite

NIL

3. Link to the other courses

NIL

4. Course Educational Objectives

Students, after undergoing this course would

- Know the principles, methods, areas of usage, possibilities and limitations as well as environmental effects of the additive manufacturing technologies
- Be familiar with the characteristics of various materials that are used in additive manufacturing.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Classify the types of additive manufacturing techniques and materials for product development	K3
CO2	Select and use CAD for part orientation and slicing for reverse engineering applications	K3
CO3	Illustrate the operating principles, capabilities, and limitations of Solid and Liquid based additive manufacturing systems.	K3
CO4	Illustrate the operating principles, capabilities, and limitations of Powder based additive manufacturing systems.	K3
CO5	Identify the suitable additive manufacturing technique for bio-manufacturing applications	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H										
CO2	H	H	L									
CO3	H	H				L	M					
CO4	H	H				L	M					
CO5	H	H	L									

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION L-9

Introduction to Additive Manufacturing (AM) - Historical Background – Classification of Additive Manufacturing Processes – Process Chain - Additive Manufacturing Technology in Product Development – Materials in Additive Manufacturing.

UNIT II REVERSE ENGINEERING L-9

Steps in Reverse Engineering – Digitization Technique – Model Reconstruction – Data Processing – Part Orientation and Support Generation - Model Slicing – Tool Path Generation – Softwares for Additive Manufacturing Technology.

UNIT III SOLID & LIQUID BASED ADDITIVE MANUFACTURING SYSTEM L-9

Introduction to Solid & Liquid based system – Fused Deposition Modeling (FDM) & Stereo lithography Apparatus (SLA) – Principle, Process, Advantages, Disadvantages and Application.

UNIT IV POWDER BASED ADDITIVE MANUFACTURING SYSTEM L-9

Introduction to Powder based system - Selective Laser Sintering (SLS) & Laser Engineered Net Shaping (LENS) – Principle, Process, Advantages, Disadvantages and Application.

UNIT V APPLICATION OF ADDITIVE MANUFACTURING L-9

Applications of Additive Manufacturing in Aerospace, Automotive, Manufacturing and Bio Medical Industry with case studies – Bio Additive Manufacturing - Computer Aided Tissue Engineering (CATE).

TOTAL: 45 PERIODS

8. Text Books

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

9. References

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

COURSE CODE	DIGITAL MANUFACTURING AND DESIGN	L	T	P	C
10213ME118		3	0	0	3

1. Preamble

This course will cover fundamental concepts of digital manufacturing and advanced tool design techniques. It will endow students with abilities which combines CAD design, digital manufacturing, robotics, sensors & data and analytics to redefine industrial production.

2. Pre-requisite

NIL

3. Link to the other courses

NIL

4. Course Educational Objectives

Students, after undergoing this course would

- To identify and describe advanced tool techniques and their roles in mechanical components.
- To recognize the feasibility of applying a digital manufacturing for the particular problem.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Sketch the product design ideas into 2D drawings using CAD/CAM/CAE technologies	K3
CO2	Draw 3D models of the given design ideas using CAD tools	K3
CO3	Develop a numerical control part program to machine the surfaces of the given drawing using CAE tool	K3
CO4	Use digitizing techniques for data acquisition to reverse engineering applications	K3
CO5	Classify the types of additive manufacturing techniques and materials for product development	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	M		M							
CO2	H	H	M		M							
CO3	H	H	M		M							
CO4	H	M										
CO5	H	M										

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I CONCEPTION AND DEVELOPMENT OF PRODUCTS L-9

Design processes and methods. CAD/CAM/CAE technologies and product lifecycle management (PLM). Concepts generation and embodiment. Expression of product design ideas using 2D sketches.

UNIT II COMPUTER AIDED DESIGN (CAD) L-9

3D modeling. Parametric design. Assembly modeling. Render the appearance of a product. CAD and additive manufacturing.

UNIT III COMPUTER AIDED ENGINEERING (CAE) L-9

Introduction to automatic NC part program generation from CAD models using standard CAD/CAM software for machining of surfaces, moulds and dies etc

UNIT IV REVERSE ENGINEERING L-9

General methodology: point clouds, meshes (NURBS surface models and parametric CAD models). Digitizing methods and main technologies: applications and selection of reverse engineering systems. Hardware and software involved. Reverse engineering and additive manufacturing.

UNIT V ADDITIVE MANUFACTURING (AM) L-9

Introduction to additive Manufacturing – Classification of AM – Process Chain – Additive Manufacturing Technology in Product Development – Materials for AM – Softwares Used In AM.

TOTAL: 45 PERIODS

8. Text Books

1. K. T. Ulrich and S. D. Eppinger, Product Design and Development, 6th Ed., McGraw-Hill education, 2015. ISBN-13:
2. V. Raja and K. J. Fernandes (eds.), Reverse Engineering. An Industrial Perspective, 1st Ed., Springer-Verlag London, (2009).

9. References

1. Z. Zhou, S. Xie, and D. Chen, Fundamentals of Digital Manufacturing Science, 1st Ed., Springer-verlag London, 2012.
2. C. K. Chua, K. F. Leong, and C. S. Lim, Rapid Prototyping: Principles and Applications, 3rd Edition.

COURSE CODE	MACHINE LEARNING FOR INDUSTRY 4.0	L	T	P	C
10213ME119		3	0	0	3

1. Preamble

This course will cover fundamental concepts of digital manufacturing and advanced tool design techniques. It will endow students with abilities which combines CAD design, digital manufacturing, robotics, sensors & data and analytics to redefine industrial production.

2. Pre-requisite

NIL

3. Link to the other courses

NIL

4. Course Educational Objectives

Students, after undergoing this course would

- To identify and describe advanced tool techniques and their roles in mechanical components.
- To recognize the feasibility of applying a digital manufacturing for the particular problem.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Compare the Industry 4.0 with traditional manufacturing facilities	K3
CO2	Explain the applications of IoT in smart manufacturing devices	K2
CO3	Differentiate the Distance, Density, and Hierarchical clustering methods used in smart manufacturing	K3
CO4	Describe the applications of augmented reality devices in smart manufacturing	K2
CO5	Explain the applications Human-Robot collaboration in the field of manufacturing	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	M										
CO2	M	M										
CO3	H	H										
CO4	H	H										
CO5	M	H										

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION TO INDUSTRY 4.0 L-9

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

UNIT II ROAD TO INDUSTRY 4.0 L-9

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

UNIT III CLUSTERING L-9

Distance measures Different clustering methods (Distance, Density, Hierarchical) Iterative distance-based clustering; Dealing with continuous, categorical values in K-Means Constructing a hierarchical cluster K-Medoids, k-Mode and density-based clustering Measures of quality of clustering.

UNIT IV AUGMENTED REALITY IN MANUFACTURING L-9

AR-devices an Overview (different versions, Videos), Use case 1: Integrating Design and Manufacturing, Use case 2: Training Shop floor Workers, Use case 3: Supporting complex Assembly Operations, Use case 4: Service and Maintenance, Use case 5: Supporting complex Sales solutions, Use case 6: Executive Oversight and Data Visualisation, Applications with Augmented Reality (examples of existing or future applications in the field of manufacturing).

UNIT V HUMAN-ROBOT COLLABORATION L-9

Human-Robot Collaboration in Industry, Example video Airplane Assembly and others, Collaborative Robots, tasks, Collaborative Robots, examples (Yumi, IIWA, UR, Panda, ...), Types of Human-Robot Collaboration, Safety of Human-Robot Collaboration (Standards and Norms in the EU), Applications with Collaborative Robots (examples of existing or future applications in the field of manufacturing).

TOTAL: 45 PERIODS

8. Text Books

1. Stuart Russell and Peter Norvig, "Artificial Intelligence: A Modern Approach" , 3rd Edition, Prentice Hall
2. Trivedi, M.C., "A Classical Approach to Artificial Intelligence", Khanna Publishing House, Delhi.

9. References

1. Andrew Kusiak, Intelligent Manufacturing Systems, Prentice Hall, 1990.
2. Kesheng Wang, Applied Computational Intelligence in Intelligent Manufacturing Systems, Advanced Knowledge International, 2005.

COURSE CODE	PRODUCT DEVELOPMENT	L	T	P	C
10213ME120		3	0	0	3

1. Preamble

This course will cover fundamental concepts of Product Development and Advanced tool design techniques. This course is designed to provide the knowledge about the concepts of various tools and approaches available for product design and process development.

2. Pre-requisite

NIL

3. Link to the other courses

NIL

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the concepts of tools and techniques in the Project based Product Development area of the Engineering Services industry.
- Relate the engineering topics into real world engineering applications.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Explain the various trends affecting the product design and process	K2
CO2	Identify the basic requirements of system design and modelling to create new product	K2
CO3	Compare the different techniques of design creation and testing	K3
CO4	Explain the methods of model creation, integration between Software & hardware, and confidentiality.	K2
CO5	Describe the Human-Robot Collaboration design procedure for industrial applications	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	M										
CO2	H	M										
CO3	H	M										
CO4	H	M										
CO5	H	M										

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION

L-9

Introduction to Product Development Methodologies and Management: Overview of Products and Services- Types of Product Development- Overview of Product Development methodologies - Product Life Cycle - Product Development Planning and Management.

UNIT II REQUIREMENTS AND SYSTEM DESIGN

L-9

Requirement Engineering: Types of Requirements - Requirement Engineering- Analysis - Traceability Matrix and Analysis - Requirement Management - System Design & Modeling: Introduction to System Modeling- Introduction to System Optimization - System Specification - Subsystem Design - Interface Design.

UNIT III DESIGN AND TESTING

L-9

Introduction to Concept generation Techniques - Concept Screening & Evaluation - Concept Design - S/W Architecture- Hardware Schematics and simulation - Detailed Design: Component Design and Verification - High Level Design/Low Level Design of S/W Programs - S/W Testing - Hardware Schematic- Component design - Layout and Hardware Testing.

UNIT IV IMPLEMENTATION, INTEGRATION & BUSINESS DYNAMICS L-9

Introduction to Manufacturing /Purchase and Assembly of Systems- Integration of Mechanical, Embedded and S/W systems- Introduction to Product verification and validation processes - Product Testing standards, Certification and Documentation, Intellectual Property Rights and Confidentiality- Security and configuration management.

UNIT V DESIGN FOR MANUFACTURING AND PRODUCT DEVELOPMENT L-9

Human-Robot Collaboration in Industry, Example video Airplane Assembly and others, Collaborative Robots, tasks, Collaborative Robots, examples (Yumi, IIWA, UR, Panda, ...), Types of Human-Robot Collaboration, Safety of Human-Robot Collaboration (Standards and Norms in the EU), Applications with Collaborative Robots (examples of existing or future applications in the field of manufacturing).

TOTAL: 45 PERIODS

8. Text Books

1. Ulrich, Karl, and Steven Eppinger. Product Design and Development. 3rd ed. New York, NY: McGraw-Hill, 2003. ISBN: 9780072471465.
2. Thomke, Stefan, and Ashok Nimgade. "IDEO Product Development." Boston, MA: Harvard Business School Case 9-600-143, June 22, 2000.

9. References

1. George E.Dieter, Linda C.Schmidt, "Engineering Design", McGraw-Hill International Edition, 4th Edition, 2009, ISBN 978-007-127189-9

2. Kevin Otto, Kristin Wood, "Product Design", Indian Reprint 2004, Pearson Education, ISBN. 9788177588217.
3. Yousef Haik, T. M. M. Shahin, "Engineering Design Process", 2nd Edition Reprint, Cengage Learning, 2010, ISBN 0495668141.
4. Clive L.Dym, Patrick Little, "Engineering Design: A Project-based Introduction", 3rd Edition, John Wiley & Sons, 2009, ISBN 978-0-470-22596-7. Product Design Techniques in Reverse Engineering and New Product Development, KEVIN OTTO & KRISTIN WOOD, Pearson Education (LPE), 2001.

Theme 2: Energy Engineering

COURSE CODE	ENERGY RESOURCES	L	T	P	C
10213ME121		3	0	0	3

1. Preamble

This course will increase students' knowledge of various energy resources, particularly from renewable sources, and will enable students to understand the need for, and use of, techniques for its applications.

2. Pre-requisite

NIL

3. Link to the other courses

NIL

4. Course Educational Objectives

Students, after undergoing this course would

- Describes the importance of utilizing renewable resources.
- Explains and provides information on solar, wind, biomass, geothermal, and ocean energy resources and technologies.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Explain the basic principle of solar energy, measurement of solar radiation, solar collector and its performance.	K2
CO2	Illustrate the principle of solar energy storage, applications of solar energy and photovoltaic energy conversion.	K3
CO3	Discuss wind energy conversion and various biomass energy conversion methods.	K2
CO4	Illustrate the geothermal energy conversion and various ocean energy conversion technologies.	K3
CO5	Summarize the principle of different direct energy conversion technologies.	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	M					H					
CO2	M	H					H					
CO3	M	M					H					
CO4	M	M					H					
CO5	M	H					H					

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I PRINCIPLES OF SOLAR RADIATION L-9

The solar energy, physics of the sun, the solar constant, extraterrestrial and terrestrial solar radiation, solar radiation on tilted surface, Instruments for measuring solar radiation and sun shine, Solar energy collection: Flat plate, evacuated tube, and concentrating collectors and its classification, orientation and thermal analysis.

UNIT II SOLAR ENERGY STORAGE AND APPLICATIONS L-9

Different methods of energy storage, sensible, latent heat, and stratified storage, Solar applications - solar heating/cooling technique, solar ponds, solar distillation/stills, solar chimney, and drying, photovoltaic energy conversion; behaviour of solar cells; cell properties; system components; applications; grid connection; system design.

UNIT III WIND ENERGY & BIO –MASS L-9

Sources and potentials, horizontal and vertical axis windmills, performance characteristics, interaction of wind and rotor; fatigue; process of electricity generation and wind farms.

BIO-MASS: Principles of Bio-Conversion, Anaerobic/aerobic digestion, types of Bio-gas digesters, gas yield, combustion characteristics of bio-gas, utilization for cooking, I. C. Engine operation and economic aspects

UNIT IV GEOTHERMAL & OCEAN ENERGY L-9

Resources, types of wells, methods of harnessing the energy, Ocean energy: OTEC, Principles utilization, setting of OTEC plants, thermodynamic cycles. Tidal and wave energy: Potential and conversion techniques, mini-hydel power plants, and their economics.

UNIT V DIRECT ENERGY CONVERSION L-9

Need for DEC, Carnot cycle, limitations, principles of DEC. Thermo-electric generators, seebeck, peltier and joule Thomson effects, Figure of merit, materials, applications, MHD generators, principles, dissociation and ionization, hall effect, magnetic flux, MHD accelerator, MHD Engine, power generation systems, electron gas dynamic conversion, economic aspects. Fuel cells, principles, faraday's laws, thermodynamic aspects.

TOTAL: 45 PERIODS

8. Text Books

1. S.Rao, Non-conventional, renewable and conventional energy, Khanna Publishers, New Delhi, 2005
2. Boyle, G. Renewable energy, Power for a sustainable future. Oxford University press, Oxford, UK, 2004.

9. References

1. John Twidell & Tony Weir, Renewable Energy resources, Routledge, 2015

2. Kemp, W.H. The Renewable Energy Handbook, Aztext Press Ontario, Canada, 2009
3. Duffie, J. A. & W. A. Beckman, Solar Engineering of Thermal Processes, 3rd ed. John Wiley & Sons, Inc. 2006.

COURSE CODE	ENERGY CONVERSION TECHNIQUES	L	T	P	C
10213ME122		3	0	0	3

1. Preamble

This course makes an attempt to bring students in direct contact with different types of power plants and their working. Empower the students to amalgamate their knowledge of basic engineering thermodynamics, heat transfer and thermal power engineering.

2. Pre-requisite

NIL

3. Link to the other courses

NIL

4. Course Educational Objectives

Students, after undergoing this course would

- Describes the working of steam power plant and different types of boilers
- Explains and provides knowledge on the components of hydel and nuclear power plants.
- Analysis of various types of non-conventional energy resources for power generation
- Discusses the various methods of gas turbine power plants.
- Description of power plant economics and the various effects of pollution.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Illustrate the layout, types, and components of the steam power plant	K3
CO2	Draw and explain the layout, essential components, and working of diesel and gas power plants	K3
CO3	Illustrate the types, essential components, and working of hydel and nuclear power plants	K3
CO4	Draw and explain the layout, essential components, and working of non-conventional power generation systems	K3
CO5	Estimate the economics of power plants and explain pollution control methods.	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	M					L	L				
CO2	H	M					L	L				
CO3	H	M	L				L	L				
CO4	H	M	L				H	L				
CO5	H	M	L				M	H			H	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I STEAM POWER PLANTS L-9

Layout of steam power plants & various components, Four circuits of steam Power plant, La Mount, Loeffler, Benson & Velox boilers, Co –generation. Fuel and Ash handling, Pulverisers, steam condensers– different types, cooling towers – Different types, Drought system – different types, Merits and Demerits of steam power plants.

UNIT II DIESEL AND GAS TURBINE POWER PLANTS L-9

Layout of Diesel power plants, components, selection of Engine type, Application, Advantages and Disadvantages of Diesel power plants. Layout of Gas turbine power plants, Essential components, Fuels, types of gas turbine plants, combine cycle power generation, merits and demerits of gas turbine power plants.

UNIT III HYDEL AND NUCLEAR POWER PLANTS L-9

Layout of hydel power plants, Essential elements, selection of turbines, governing of water turbine, pumped storage hydel plants, Merits and Demerits of hydel power plants.

Layout of Nuclear power plant, Nuclear energy – Fission and Fusion, Nuclear reactor – Essential elements, Types of reactors– Pressurized water reactor, boiling water reactor, Gas cooled reactor, Waste disposal and safety, merits and demerits of nuclear power plants.

UNIT IV NON- CONVENTIONAL POWER GENERATION L-9

Geothermal power plants, Ocean thermal energy conversion (OTEC), Tidal power plants, wind power plants, solar thermal energy conversion, energy from Biomass, merits and demerits of various non– conventional power generation systems.

UNIT V POWER PLANT ECONOMICS AND POLLUTION L-9

Load curve, Load duration curve, and cost of electrical energy, Fixed and operating costs, Energy rate (tariff), types of tariffs, Economics of load sharing, comparison of economics of various power plants. Pollution from thermal and other power plants.

TOTAL: 45 PERIODS

8. Text Books

1. P. K. Nag, "Power Plant Engineering", Tata McGraw–Hill Education, 2017.
2. R.K.Rajput, "A Text Book of Power system engineering", Laxmi Publications; Eleventh edition (2020).

9. References

1. Manoj kumar Gupta "Power plant engineering", MS/PHI, 2012.

COURSE CODE	ENERGY STORAGE SYSTEMS	L	T	P	C
10213ME123		3	0	0	3

1. Preamble

To enable the students to acquire the knowledge of energy storage systems for better utility of energy resources for diverse applications and to meet out the pollution control norms.

2. Pre-requisite

NIL

3. Link to the other courses

NIL

4. Course Educational Objectives

Students, after undergoing this course would

- Store the energy with optimum cost
- Explains and provides knowledge on the energy storage systems
- Discuss the application of energy storage for better efficiency.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Compare the different types of energy storage techniques and materials	K3
CO2	Illustrate the use of sensible heat based storage systems for the application of power plant and packed beds.	K3
CO3	Illustrate the use of latent heat storage systems	K3
CO4	Describe the various mode of energy storage system for better utilization	K2
CO5	Summarize the various applications of energy storage systems for maximizing the overall efficiency.	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	H					M					
CO2	M	H	M				M					
CO3	M	H	M				M					
CO4	M	M					M					
CO5	M	M					M					

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION

L-9

Necessity of thermal storage – classification of energy storage devices – comparison of energy storage technologies - seasonal thermal energy storage - storage materials.

UNIT II SENSIBLE HEAT STORAGE SYSTEM

L-9

Basic concepts and modeling of heat storage units - modeling of simple water and rock bed storage system – use of TRNSYS – pressurized water storage system for power plant applications – packed beds.

UNIT III LATENT HEAT STORAGE SYSTEMS

L-9

Modeling of phase change problems – temperature-based model - enthalpy model - porous medium approach - conduction dominated phase change – convection dominated phase change.

UNIT IV OTHER ENERGY STORAGE SYSTEMS

L-9

Electrical Energy storage – super capacitors, Magnetic Energy storage - Superconducting systems, Mechanical - Pumped hydro, flywheels and pressurized air energy storage, Chemical - Hydrogen production and storage.

UNIT V APPLICATIONS

L-9

Specific areas of application of energy storage – food preservation – waste heat recovery – solar energy storage – green house heating – power plant applications – drying and heating for process industries.

TOTAL: 45 PERIODS

8. Text Books

1. Ibrahim Dincer and Mark A. Rosen, Thermal Energy Storage Systems and Applications, John Wiley & Sons 2002.
2. Schmidt.F.W and Willmott.A.J, Thermal Storage and Regeneration, Hemisphere Publishing Corporation, 1981.

9. References

1. Lunardini V. J., Heat Transfer in Cold Climates, John Wiley and Sons 1981.
2. Robert Huggins, Energy Storage: Fundamentals, Materials and Applications, Springer Publications, 2015.
3. Alfred Rufer, Energy Storage: systems and components, CRC Press, 2017.
4. Ahmed Faheem Zobaa, Energy Storage - Technologies and Applications, InTech, 2013.
5. J. Jensen and B. Sorenson, Fundamentals of Energy Storage, Wiley-Interscience, New York, 1984.

COURSE CODE	ENERGY EFFICIENT BUILDINGS	L	T	P	C
10213ME124		3	0	0	3

1. Preamble

To learn about green building concepts those are applicable to modern buildings; to familiarize students with the fundamental theories, materials, and construction techniques; and to create energy efficient buildings.

2. Pre-requisite

NIL

3. Link to the other courses

NIL

4. Course Educational Objectives

Students, after undergoing this course would

- Perform energy audits in any buildings
- Give suggestion for conservation measures
- Integrate the renewable energy systems
- Learn passive cooling in buildings

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Interpret the past and present energy scenario in India and the methodology involved in energy audit	K2
CO2	Illustrate the energy efficient materials and techniques for building and envelop application	K2
CO3	Describe the applications related to heating, ventilation and air conditionings	K2
CO4	Discuss the heat transmission techniques in buildings and packaging	K2
CO5	Explain the passive cooling methods and use of renewable energy on building applications	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	L					H					
CO2	M	H	M				H					
CO3	M	H	M				H					
CO4	M	M	M				H					
CO5	M	H	M				H					

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION TO ENERGY CONSERVATION L-9

Past and present energy scenario of world - Energy consumption in India - Building science and its significance - Energy audit -need – types - benefits - methodology and barriers.

UNIT II LANDSCAPE AND BUILDING ENVELOPS L-9

Energy efficient Landscape design - Micro-climates – various methods – Shading, water bodies. Building envelope: Building materials, Envelope heat loss and heat gain and its evaluation, paints, Insulation, Design methods and tools.

UNIT III HEATING, VENTILATION AND AIR-CONDITIONING L-9

Natural Ventilation, Passive cooling and heating - Application of wind, water and earth for cooling, evaporative cooling, radiant cooling – Hybrid Methods – Energy Conservation measures, Thermal Storage integration in buildings.

UNIT IV HEAT TRANSMISSION IN BUILDINGS L-9

Surface co-efficient: air cavity, internal and external surfaces, overall thermal transmittance, wall and windows; Heat transfer due to ventilation/infiltration, internal heat transfer; Sol-air temperature; Decrement factor; Phase lag. Design of day lighting; Estimation of building loads: Computer packages for carrying out thermal design of buildings and predicting performance.

UNIT V PASSIVE COOLING & RENEWABLE ENERGY IN BUILDINGS L-9

Passive cooling concepts: Evaporative cooling, radiative cooling; Application of wind, water, and earth for cooling; Shading, paints and cavity walls for cooling; Roof radiation traps; Earth air tunnel. Introduction of renewable sources in buildings, solar water heating, small wind turbines, stand-alone PV systems.

TOTAL: 45 PERIODS

8. Text Books

1. Krieder J. and Rabi A., "Heating and Cooling of buildings: Design for Efficiency", Mc Graw Hill, 1994.
2. Ursula Eicker, "Solar Technologies for buildings", Wiley publications, 2003.
3. Guide book for National Certification Examination for Energy Managers and Energy Auditors (Could be downloaded from www.energymanagertraining.com)

9. References

1. Sodha M., Bansal, N.K., Bansal,P.K., Kumar, A.. and Malik, M.A.S., "Solar Passive Buildings", Pergamon Press, 1986.
2. Koenigsberger, O.H., Ingersoll, T.G., Mayhew Alan and Szokolay, S. V., "Manual of Tropical Housing and Building part 1: Climatic Design", OLBN 0 00212 0011, Orient Longman Limited, 1973.
3. Bureau of Indian Standards, I.S. 11907 –1986 Recommendations for calculation of Solar Radiation Buildings, 1986.

4. Givoni, B., "Man, Climate and Architecture", Elsevier, Amsterdam, 1986.
5. Smith, R. J., Phillips, G.M. and Sweeney, M. "Environmental Science", Longman Scientific and Technical, Essex, 1982.

COURSE CODE	INSTRUMENTATION IN ENERGY SYSTEMS	L	T	P	C
10213ME125		3	0	0	3

1. Preamble

This course will provide the various concepts in instrumentation towards energy systems as well as the processing of data for further analysis.

2. Pre-requisite

NIL

3. Link to the other courses

NIL

4. Course Educational Objectives

Students, after undergoing this course would

- Do error analysis for any kind of measurements
- Perform systematic way of measurements related to flow, temperature, and pressure
- Provide the quality of air as well as the exhaust gas composition
- Calculate electricity consumption by various electrical devices.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Summarize the static and dynamic characteristics of error analysis instruments	K2
CO2	Illustrate the various flow measurements devices for compressible and incompressible fluids	K2
CO3	Demonstrate the techniques for temperature measurements using contact and non-contact type	K2
CO4	Identify the different compositions of components in air/exhaust gases using air pollution measurement devices	K2
CO5	Discuss the procedure for determination of electrical power as well as the data processing of signals	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	L					H					
CO2	H	M					H					
CO3	H	M					H					
CO4	H	M					H					
CO5	H	M					H					

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION

L-9

Instrument classification, static and dynamic characteristics of instruments, experimental error analysis, statistical analysis, uncertainty, Variable resistance transducers, capacitive transducers, piezoelectric transducers, photoconductive transducers, photovoltaic cells, ionization transducers, Hall effect transducers.

UNIT II FLOW MEASUREMENT

L-9

Flow measurement – variable head flow meter – rota meters, electromagnetic flow meters, hot-wire anemometers, hot film transducers, Laser Doppler anemometer, Ultrasonic flow meters, flow visualization methods.

UNIT III TEMPERATURE MEASUREMENT

L-9

Temperature measurement – Bimaterials, pressure thermometers, thermocouples, RTD, thermistors, and pyrometry, pyrometers – calibration of pressure measuring equipments.

UNIT IV AIR POLLUTION MEASUREMENT

L-9

Air pollution and Miscellaneous Measurements- Particulate sampling techniques, SO₂, Combustion Products, Opacity, odour measurements - Measurement of liquid level, Humidity, O₂, CO₂ in flue gases- pH measurement.

UNIT V POWER MEASUREMENT AND PROCESSING

L-9

Moving Iron/coil, Energy measurement, power factor meter-Analog signal conditioning, Amplifiers, Instrumentation amplifier, A/D and D/A converters, Digital data processing and Data acquisition system.

TOTAL: 45 PERIODS

8. Text Books

1. A.K.Sawhney. PuneetSawney: A course in Mechanical Measurements and Instrumentation. DhanpatRai&Co 2002
2. Bechwith. Marangoni. Lienhard:Mechanical Measurements Fifth edition. Addison-Wesley 2000

9. References

1. Holman, J.P., "Experimental methods for engineers", Tata McGraw-Hill, 7th Edition, 2007.
2. Prebrashensky V., "Measurement and Instrumentation in Heat Engineering", Vol.1, MIR Publishers, 1980.
3. Raman, C.S. Sharma, G.R., Mani, V.S.V., "Instrumentation Devices and Systems", 2nd Edition, Tata McGraw-Hill., 2001.
4. Morris. A.S, "Principles of Measurements and Instrumentation", 3rd Edition, Butterworth-Heinemann, 2001.

COURSE CODE	BIO ENERGY ENGINEERING	L	T	P	C
10213ME126		3	0	0	3

1. Preamble

This course provides a knowledge base for the students, in bio energy engineering related to bio-gas, thermo chemical conversion and utilization of agricultural waste.

2. Pre-requisite

NIL

3. Link to the other courses

NIL

4. Course Educational Objectives

Students, after undergoing this course would

- To understand the principle in conversion of biogas from the waste products such as domestic and agricultural
- To analyze the system for optimum production of bio energy

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Explain the classification, properties, storing and handling of biomass	K2
CO2	Describe the techniques for generation of biogas from waste	K2
CO3	Discuss the chemical processing method for maximum utilization of energy	K2
CO4	Explain the need of thermo-chemical principles for biomass applications	K2
CO5	Identify the various agricultural waste for energy extraction	K2

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	M					H					
CO2	M	H					H					
CO3	M	H					H					
CO4	M	H					H					
CO5	M	H					H					

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION

L-9

Sources and Classification. Chemical composition, properties of biomass. Energy plantations. Size reduction, Briquetting, Drying, Storage and handling of biomass.

UNIT II BIOGAS

L-9

Feedstock for biogas, Microbial and biochemical aspects- operating parameters for biogas production. Kinetics and mechanism- High rate digesters for industrial waste water treatment.

UNIT III THERMO CHEMICAL CONVERSION

L-9

Thermo chemical conversion of lignocelluloses biomass, Incineration, Processing for liquid fuel production. Pyrolysis -Effect of particle size, temperature, and products obtained.

UNIT IV THERMO CHEMICAL PRINCIPLES

L-9

Thermo chemical Principles: Effect of pressure, temperature, steam and oxygen - Fixed and fluidized bed Gasifiers - Partial gasification of biomass by circulating fluidized bed.

UNIT V AGRICULTURAL WASTE UTILIZATION

L-9

Different Types of Agricultural Industrial Wastes - Combustion of woody biomass- Design of equipment. Cogeneration using bagasse- Case studies: Combustion of rice husk - Production of pure silica, silicon, furfural, ceramics and paper from agricultural wastes.

TOTAL: 45 PERIODS

8. Text Books

1. Chakraverthy A, "Biotechnology and Alternative Technologies for Utilization of Biomass or Agricultural Wastes", Oxford & IBH publishing Co, 1989.
2. D. Yogi Goswami, Frank Kreith, Jan. F .Kreider, "Principles of Solar Engineering", 2nd Edition, Taylor & Francis, 2000, Indian reprint, 2003[chapter 10]
3. Mital K.M, "Biogas Systems: Principles and Applications", New Age International publishers (P) Ltd., 1996.

9. References

1. Nijaguna, B.T., Biogas Technology, New Age International publishers (P) Ltd.,2002
2. VenkataRamana P and Srinivas S.N, "Biomass Energy Systems", Tata Energy Research Institute, 1996.
3. Rezaiyan. J and N. P. Cheremisinoff, "Gasification Technologies, A Primer for Engineers and Scientists", Taylor & Francis, 2005
4. Khandelwal. K. C.and Mahdi S. S, "Bio-Gas Technology", Tata McGraw-Hill Pub. Co.Ltd, 1986.
5. Renu Agrawal, "Utilization of Agricultural Waste for the Production of High Valued Products", CRC Press, 2020.

COURSE CODE	ENERGY MANAGEMENT	L	T	P	C
10213ME127		3	0	0	3

1. Preamble

This course provides an update, to the knowledge base of the students, in essential Energy Management. Students may gain knowledge on Energy Auditing, Waste Heat Recovery, HVAC, Lighting systems and Maintenance of Energy Systems.

2. Pre-requisite

NIL

3. Link to the other courses

NIL

4. Course Educational Objectives

Students, after undergoing this course would

- Understand the basic principles of Energy Auditing and its types involved in Energy Sector.
- Understand the Energy Management Concepts in Waste Heat Recovery Systems, HVAC Systems, and Lighting Systems etc. and to gain knowledge about the maintenance of Energy Systems.

5. Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Differentiate the types of energy and energy-consuming devices used in energy storage management	K3
CO2	Describe the methods of energy auditing (simple payback period, Return on Investment, Net present value & Future value method)	K2
CO3	Elaborate the working principle of waste heat recovery devices and energy conservation methods used in HVAC systems	K2
CO4	Illustrate the types of energy conservation methods applied in lighting systems	K3
CO5	Apply energy efficient design for conservation of energy in building applications.	K3

(K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5 – Evaluate; K6 - Create)

6. Correlation of COs with POs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	H				M	H					
CO2	M	H				M	H	H				
CO3	H	H				M	H	H			M	
CO4	H	H				M	H	H			M	
CO5	H	H				M	H	H			M	

(H- High; M-Medium; L-Low)

7. Course Content

UNIT I INTRODUCTION TO ENERGY MANAGEMENT L-9

Basics of energy and its various forms - Introduction to Energy Consuming Devices – Energy Management – Effective Energy Management – Top Management Commitment and Support – Energy Manager – Responsibilities and Duties – Integrated Energy Policy - National Action Plan on Climate Change – Guiding principle – Eight National Missions.

UNIT II ENERGY AUDITING AND ECONOMIC ANALYSIS L-9

Energy Audit – Definition – Need, Types of energy audit – Understanding energy costs – Energy audit report – Benchmarking – Instrumentation and metering for energy audit – BEE Regulations – Industrial Audits – Commercial Audits – Residential audits – Economic Analysis – Simple Payback Period – Return on Investment – Net Present Value method – Future Value method.

UNIT III WASTE HEAT RECOVERY AND HVAC SYSTEMS L-9

Waste Heat Recovery – Classification and Application – Benefits of Waste Heat Recovery – Development of a Waste Heat Recovery System – Cogeneration – Commercial Waste Heat Recovery Devices – Heat Exchangers – Concept – Types, by flow design, by construction, by application – Human Thermal Comfort – HVAC System Types – Cooling Equipment – Energy Conservation Opportunities.

UNIT IV LIGHTING SYSTEM L-9

Lighting Fundamentals – Basic Parameters and Terms in Lighting System – Light Source and Lamp types – Illuminance levels – Lighting design for interiors – General energy saving opportunities Energy efficient lighting controls - Standards and labeling programs for FTL Lamps – Day Lighting – Use of Alternative Energy – Solar Energy – Wind Energy.

UNIT V ENERGY CONSERVATION IN BUILDINGS AND ECBC L-9

Building definition – Energy Conservation Building Code – Compliance approaches – ECBC guidelines on building envelop – ECBC guidelines on service hot water – ECBC guidelines on lighting – ECBC guidelines on electrical power – Building water pumping systems – Uninterruptible power supply – Building Management Systems – Star rating of Buildings – Energy efficiency measures in Buildings.

TOTAL: 45 PERIODS

8. Text Books

1. General Aspects of Energy Management and Energy Audit - Guide book for National Certification Examination for Energy Managers and Energy Auditors, by Bureau of Energy Efficiency, Fourth Edition, 2015.
2. Energy Efficiency in Thermal Utilities – Guide book for National Certification Examination for Energy Managers and Energy Auditors, by Bureau of Energy Efficiency, Fourth Edition, 2015.

3. Energy Efficiency in Electrical Utilities Book 03 Final - Guide book for National Certification Examination for Energy Managers and Energy Auditors, by Bureau of Energy Efficiency, Fourth Edition, 2015.
4. Energy Management Handbook, Vol I and II, Wayne C. Turner, Steve Doty, Eighth Edition, 2013, Fairmont Press.

9. References

1. Handbook of Energy Audit, Sonal Desai, Mc Graw Hill Education.
2. Energy Engineering and Management, Amlan Chakrabarti, PHI.
3. Energy Management Handbook, Jonathan H Turner.
4. Study Materials from e-Sources, related to Energy Management.