KALASALINGAM
ACADEMY OF RESEARCH AND EDUCATION
(DEEMED TO BE UNIVERSITY)
Under sec. 3 of UGC Act 1956.
Anand Nagar, Krishnankoil - 626126. Srivilliputtur (Via), Virudhunagar (Dt), Tamil Nadu | info@kalasalingam.ac.in | www.kalasalingam.ac.in

SCHOOL OF MECHANICAL, AERO,AUTO AND CIVIL ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

BACHELOR OF TECHNOLOGY

MECHANICAL ENGINEERING

CURRICULUM AND SYLLABUS

(For the Students Admitted from the Academic Year 2021-22 Onwards)

KALASALINGAM ACADEMY OF RESEARCH AND EDUCATION

VISION

To be a Centre of Excellence of International repute in education and research.

MISSION

To produce technically competent, socially committed technocrats and administrators through Quality Education and Research

DEPARTMENT OF MECHANICAL ENGINEERING

VISION

To be Recognized Globally as a Lead in Mechanical Engineering through excellence in Education and Innovative Research in Emerging areas

MISSION

To provide quality education and research with the state of the art facilities to the student

This is accomplished by:

- Enhancing the Knowledge and Expertise through Professional Programmes and Research Works.
- Endowing the Students with Academic Leadership, Communication Skills and Professional Awareness towards Social Commitment.

ABET STUDENT OUTCOMES (ASO)

ASO1: An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.

ASO2: An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.

ASO3: An ability to communicate effectively with a range of audiences.

ASO4: An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.

ASO5: An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.

ASO6: An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.

ASO7: An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

PROGRAM OUTCOMES (POs)

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 analyse 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 modelling 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 the 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: Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PSO1: PO13 - An ability to utilize the gained knowledge of mathematics and engineering sciences to real time problems involving thermal, design, manufacturing and materials domain.

PSO2: PO14 - An ability to specify, fabricate, test, operate, validate and complete documentation of any basic mechanical systems or processes.

PSO3: PO15 - An ability to apply the acquired software's skills to design and analysis of advanced mechanical systems or processes.

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DEPARTMENT OF MECHANICAL ENGINEERING (R2021)

CURRICULUM STRUCTURE

S. No	Category	Credits
I	Foundation Core Courses	**44**
II	Program Core Courses	**52**
III	Program Elective Courses	**24**
IV	University Elective courses	**16**
V	Experiential Core courses	**16**
VI	Experiential Elective courses	**8**
VII	Mandatory courses	**---**
VIII	Complimentary Skill Courses	**---**
	Total Credits	**160**

I. FOUNDATION CORE COURSES

S. No	Course Code	Course Name	Course Type	L	T	P	X	C
1.	211ENG1301	English for Engineers	T	3	0	0	0	3
2.	211PHY1301	Physics	IC-T	3	0	2	0	4
3.	211MAT1301	Calculus and Linear Algebra	IC-T	3	0	2	0	4
4.	211MEC1201	Introduction to Engineering Visualization	PC	0	0	2	3	2
5.	211CSE1401	Problem Solving using computer Programming	IC-P	1	0	4	0	3
6.	211EEE1301	Basic Electrical and Electronics Engineering	IC-T	3	0	2	0	4
7.	211BIT1101	Biology for Engineers	T	3	0	0	0	3
8.	211CHY1301	Chemistry	IC-T	3	0	2	0	4
9.	211MAT1303	Multiple Integration, ODE, and complex variable	IC-T	3	0	2	0	4
10.	211MEC1401	Sustainable Design and Manufacturing	IC-P	1	0	2	3	3
11.	211CSE1402	Python Programming	IC-P	1	0	4	0	3
12.	211ECE1400	IoT sensors and devices	IC-P	1	0	2	0	2
13.	211MEC13 01	Innovation and Entrepreneurship	IC-T	1	0	0	3	2
14.	211MAT1302	Statistics for Engineers	IC-T	2	0	2	0	3
Total								**44**

II. PROGRAM CORE COURSES

S. No	**Course Code**	**Course Name**	**Course Type**	**L**	**T**	**P**	**X**	**C**
1.	212MEC1301	Principle of Robotics and Industrial Automation	IC-T	2	0	2	0	3
2.	212MEC1304	Manufacturing Processes	IC-T	2	0	2	0	3
3.	212MEC1305	Engineering Thermodynamics	T	3	0	0	3	4
4.	212MEC1106	Engineering Mechanics	T	3	0	0	0	3

5.	212MEC2107	Strength of Materials	TC	3	1	0	0	4
6.	212MEC2208	Strength of Materials Laboratory	PC	0	0	2	0	1
7.	212MEC1109	Fluid Mechanics & Machinery	TC	3	1	0	0	4
8.	212MEC1210	Fluid Mechanics and Machinery Laboratory	PC	0	0	2	0	1
9.	212MEC1111	Materials Science and Engineering	TC	3	0	0	0	3
10.	212MEC1312	Partial Differential Equations, Fourier Transform And Numerical Methods For Mechanical Engineers	IC-T	2	0	2	0	3
11.	212MEC2313	Machining and Machine Tool	IC-T	3	0	2	0	4
12.	212MEC3114	Design of Machine Elements	TC	2	1	0	0	3
13.	212MEC2315	Theory of Machines	IC-T	2	1	2	0	4
14.	212MEC3416	Finite Element Analysis	IC-P	2	0	2	3	4
15.	212MEC2317	Thermal Engineering	IC-T	2	1	2	0	4
16.	212MEC2318	Heat And Mass Transfer	IC-T	2	1	2	0	4
Total								**52**

III. PROGRAM ELECTIVE COURSES

S. No	Course Code	Course Name	Course Type	L	T	P	X	C
1.	213MEC1400	Essentials for NX designer	IC-P	0	0	2	0	1
2.	213MEC1403	Process Simulate Basic Robotics Simulation	IC-P	2	0	4	0	4
3.	213MEC1402							
3.	213MEC1401	Synchronous Modelling With NX CAD	IC-P	2	0	4	0	4
4.	213MEC2403	NX Line Designer	IC-P	1	0	6	0	4
5.	213MEC2404	Additive Manufacturing	IC-P	1	0	6	0	4
6.	213MEC2405	Industrial Internet of Things	IC-P	2	0	4	0	4

7.	213MEC2301	Big Data Analytics for Manufacturing	IC-T	3	0	2	0	4
8.	213MEC2302	Smart Manufacturing and Industry 4.0	IC-T	3	0	2	0	4
9.	213MEC2303	Production Drawing and Manufacturing Analysis	IC-T	3	0	2	0	4
10.	213MEC2304	Application of AR And VR In Manufacturing	IC-T	3	0	2	0	4
11.	213MEC2305	Cyber Physical System In Manufacturing	IC-T	3	0	2	0	4
12.	213MEC2406	Plant Simulation, Methods and Strategies	IC-P	2	0	4	0	4
13.	213MEC1307	Robotics: Fundamental Concepts and Analysis	IC-T	3	0	2	0	4
14.	213MEC2308	Automation System Design	IC-T	3	0	2	0	4
15.	213MEC2309	Automatic Control System	IC-T	3	0	2	0	4
16.	213MEC2310	Dynamics and Control Of Manipulators	IC-T	3	0	2	0	4
17.	213MEC2311	Autonomous Robots	IC-T	3	0	2	0	4
18.	213MEC2312	Intelligent Medical Robots	IC-T	3	0	2	0	4
Total								**24**

IV. UNIVERSITY ELECTIVE COURSES (To be offered to other departments)

S. No	Course Code	Course Name	Course Type	L	T	P	X	C
1.	214MEC1101	Bio and Chemical Process Safety	T	3	0	0	3	4
2.	214MEC1301	Robotics: Fundamental Concepts	IC-T	3	0	2	0	4
3.	214MEC1102	Automation System Design	T	3	0	0	3	4
4.	214MEC1103	Additive (3D) Manufacturing	T	3	0	0	3	4
5.	214MEC1104	Fundamentals Of Micro and Nano Fabrication	T	3	0	0	3	4
6.	214MEC1105	Smart Manufacturing and Industry 4.0	T	3	0	0	3	4
7.	214MEC1106	Machine Learning Engineering for Production	T					

				3	1	0	0	4
8.	214MEC1107	Data Science in Manufacturing Practice	T	3	1	0	0	4
Total								**16**

HONOURS ELECTIVE COURSES

S. No	Course Code	Course Name	Course Type	L	T	P	X	C
1.	213MEC4101	Fracture Mechanics	TC	3	1	0	0	4
2.	213MEC4102	Tribology	TC	3	1	0	0	4
3.	213MEC4103	Refrigeration and Air Conditioning	TC	3	1	0	0	4
4.	213MEC4104	Microelectromechanical Systems	TC	3	1	0	0	4
5.	213MEC4105	Robot Mechanism Design	TC	3	1	0	0	4
6.	213MEC4301	Robot Collaborative System Design	IC-T	3	0	2	0	4
7.	213MEC4106	Advanced Fluid Dynamics	TC	3	1	0	0	4
8.	213MEC4107	Analysis of Basic Manufacturing Process	TC	3	1	0	0	4
Total								**16**

V. EXPERIENTIAL CORE COURSES

Experiential Core Courses (16 credits)				
S.No.	**Course Code**	**Course Name**	**Course Type**	**Course Credits**
1	215MEC4219	Design Project - I	PC	3
2	215MEC4220	Design Project - II	PC	3
3	215MEC4221	Capstone Project	PC	10

VI. EXPERIENTIAL ELECTIVE COURSES

Experiential Elective Courses (8 credits)				
S.No.	**Course Code**	**Activity**	**Course Type**	**Course Credits**
1	216 MEC 4222	Design Challenge Competitions (SAE, Hackathon etc.,)	PC	4
2	216 MEC 4223	Project contest	PC	4
3	216 MEC 4224	Internship- 2 weeks	PC	1
4	216 MEC 4224	Internship- 4 weeks	PC	2
5	216 MEC 4225	Community Service Project	PC	3
6	216 MEC 4225	Community Service Project with Patent	PC	4

7	216MEC4226	UG Research with outcome in International Conference	PC	2
8	216MEC4226	UG Research with outcome in International Journal- Scopus indexed	PC	3
9	216MEC4226	UG Research with outcome in SCI Journal or Patent	PC	4

VII. MANDATORY COURSES

S.No	Mandatory Courses
1	Environmental Sciences
2	Indian Constitution
3	Essence of Indian Traditional Knowledge

VIII. COMPLIMENTARY SKILL COURSES

Sl. No.	Group	Course/Activity
1	I	Soft skills 1 and Soft skills 2 (or) TOEFL/IELTS/BEC, etc.,
2		Aptitude 1 and Aptitude 2 (or) GRE/GMAT/CAT/GATE, etc.,
3	II	NSS
4		Sports
5		Extra-Curricular Activity
6	III	Co-Curricular Activity
7		Value Added Courses
8		International Certification (Technical)

FOUNDATION COURSES

211MEC1201 INTRODUCTION TO ENGINEERING VISUALIZATION	L	P	X	C
	0	4	3	2
Prerequisite: Nil	**Course Category:** Foundation Core **Course Type**: Practical Course			

Course Objective(s):

This course aims to introduce the concept of graphic visualization and design of engineering products, Demonstrate skills in interpreting, and producing engineering drawings accurately

Course Outcome(s):

CO1	Draw freehand sketch of 2D and 3D models through visual observation
CO2	Construct the geometric models of various solids and surfaces
CO3	Illustrate the solid intersections and their new surfaces
CO4	Construct the sheet metal models for various engineering components
CO5	Create perspective visual models for designed products

Mapping of Course Outcome(s):

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	1	2	2	3	6	5	5	5	7	4	6	6	1,2	3,4,7	2,6
CO1	2		2										1	1	
CO2		3										1	1	1	
CO3	2		3		3		3					2	3	2	3
CO4	1	2			3		3					3	3	2	3
CO5	3		3		3		3					3	3	2	3

Course Topics:

UNIT I: INTRODUCTION AND FREE HAND SKETCHING

Drawing and its Standards - Importance of graphics – use of drafting instruments – BIS conventions and specifications – application of concept of points and straight lines projection located in the different quadrants,– Free hand sketching from industrial parts/components – preparation of software models – prepare 2D layouts for the 3D sketches

UNIT II: GEOMETRICAL METHODS IN VISUALIZATION

Geometrical and analytical methods of measuring distance between locations and objects – construction of polygonal surface and circular lamina and their projections – constructing engineering designs based on solids modelling – 3D and 2D sketches from parametric modelling

UNIT III: SOLIDS AND INTERACTION VISUALIZATIONS

Solid sections – section and intersection of prisms, pyramids, cylinder and cone by specific cutting planes conditions and solid-solid interaction - curvilinear and rectilinear surface – parametric modelling – finding physical properties

UNIT IV: SHEET METAL MODELING

Sheet metal modelling and generating development of full, frustum and truncated solid parts and modelling from 3D geometry. Real-time automotive and aerospace surface profiles/structures modelling and layout preparation

UNIT V: PRODUCT VISUALIZATION

Product visualization – technical drawing with 3D representation through isometric view and projection with scales – application of parallel and perspective projection method using CAD – final show-case model development through different perspective projection methods – lighting and aesthetics – materials property imparts and bill of material creations

Practical:
Unit I
Drawing and its Standards
Brainstorming session by comparing the industrial standards
Understanding and generating 3D drawing of disc

Unit II
Formation of 3D drawing of Wheels
Geometrical and analytical model of point
Geometrical model of projecting a Line by manual parallel projection

Unit III
Geometrical model of projecting a plane by manual parallel projection
Geometrical and analytical model of various regular solids - projecting a plane by manual parallel projection
Geometrical and analytical model of various truncated solids - projecting a plane by manual parallel projection

Unit IV
Construction and developing of curvilinear developed surface
Construction and developing and rectilinear developed surface
Combination of surfaces

Unit V
Axonometric projection
Projection of solid by perspective method (Visual ray methods)
Projection of Simple solids by perspective method (Vanishing Point method)

X- Component:

1. Free Hand Sketching on Selected Models and layouts
2. 3D Sketching of simple models
3. 2D layout preparation through parallel projection
4. *ANSI standard layout reparations*
5. *Geometrical and analytical methods for point locations*
6. *Geometrical and analytical methods for line locations*
7. Arial and mass properties of planar surfaces through CAD
8. Solid and mass properties of regular prismatic objects through CAD
9. Irregular solid characteristics through CAD
10. *Curvilinear surface creation through CAD*
11. *Rectilinear surface sketching through CAD*
12. *Model curvilinear and rectilinear surface for automotive*
13. 2D and 3D sketching with layout for simple solids
14. Parallel and perspective projection method for elevated structures
15. Projecting longer structures through Parallel and perspective projections

Text Book(s):

1. Basant Aggarwal and C. Aggarwal, Engineering Drawing, McGraw-Hill, 2013.
2. N.S. Parthasarathy, Vela Murali, Engineering Drawing, Oxford University Press, 2015.
3. K. Venugopal, Engineering Drawing + AutoCAD, New Age; Fifth edition, 2011.

Reference(s):

1. Shah, M.B., and Rana, B.C., Engineering Drawing, Pearson 2009
2. Natarajan, K.V., A Text Book of Engineering Graphics, 21st Edition, Dhanalakshmi Publishers, Chennai, 2012.
3. Paul Richard, Jim Fitzgerald., Introduction to AutoCAD 2017: A Modern Perspective, Pearson, 2016.

211MEC1401 SUSTAINABLE DESIGN MANUFACTURING	L	P	X	C
	1	2	3	3
Prerequisite: Nil	**Course Category:** Foundation Core **Course Type**: Integrated Course with Practical			

Course Objectives:

To gain knowledge about the methods, tools and techniques for development of a product in the most sustainable way

Course Outcomes:

CO1	Able to apply the sustainable design practices to improve the existing product.
CO2	Able to perform design analysis
CO3	Perform optimization on design and materials selections
CO4	Capable to prepare process layouts for the optimized products
CO5	Choose appropriate method of manufacturing the products

Mapping of Course Outcome(s):

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	1	2	2	3	6	5	5	5	7	4	6	6	1,2	3,4,7	2,6
CO1	3	3	3	2	3		2	2	2	2	1	2	3		
CO2	3	3	3	3	3	1	2	2	2	2	1	2	3		2
CO3	3	3	3	2	3		2	2	2	2	1	2	3	3	3
CO4	3	1	3	2		2	1	2	2	3	2	2	3		

Course Topics

UNIT I-INTRODUCTION TO SUSTAINABILITY

Introduction to sustainability (for all engineering fields with an emphasis on design and manufacturing),basic elements ofsustainability- Global norms and sustainable development goals- Process of product realizations

UNIT II: CONCEPTUALIZATION AND DESIGN

Need Analysis, brainstorming and strategic development – Product design (free hand sketching)- Design optimization and decision making

UNIT III: DESIGN TESTING AND VALIDATION: MODELING AND ANALYSIS

Dimensioning andtolerance, 2D sketching - 3D model, meshing- Material selection and simulation

UNIT IV: SUSTAINABLE MANUFACTURING: RESEARCH AND DEVELOPMENT

Sustainable manufacturing process- Identification of governing factors through case study analysis - Manufacturing layout preparation with justifications and alternative solutions

UNIT V: SUSTAINABLE MANUFACTURING:EXECUTION

Product(prototype)development – Mechanisms and Actuators- Performance assessment

Practical:

Unit I
Case study – 1: on mechanical engineering topic for everyone
Case study – 2: on the respective discipline
Case study – 3: on inter- disciplinary topic

Unit II
Brainstorming sessions for a real time need/demand (now on students practice it for their projects)
Preparation of freehand sketching with necessary details
Concept optimization and decision making through example

Unit III
Dimensioning and sketching practice for engineering component
CAD 3D model with some exercise
Execution of performance evaluation modelling

Unit IV
Identification of required manufacturing processes
Sustainability assessment: cost estimation, energy consumption, environmental effects and other factors
Report and job order preparation for sustainable manufacturing

Unit V
Product fabrication: Manufacturing
Product fabrication: Assembly and other processes
Real time functioning/demonstration

X Component:

1. Introduction to Altair Inspire
2. Introduction to Finite element analysis.
3. CAE driven design Process (examples with industry)
4. Basic Interaction with Inspire Graphical User Interface File Management (in every simulation different file are created) Practice Work
5. How to select and edit objects Practice Work
6. Units and Measurements Practice Work
7. Geometry Building and Sketching Geometry (2D and 3D model)
8. Sketch constraints with examples
9. Sketch simplification with some exercise
10. Meshing and boundary conditions
11. Application of loadings
12. Motion Analysis
13. Design Optimization and 3D printing for the selected product
14. CAD model development for the project
15. Analysis and Simulation results of the Final Model.

PROGRAM CORE COURSES

212MEC1301 PRINCIPLES OF ROBOTICS AND INDUSTRIAL AUTOMATION	L	T	P	X	C
	2	0	2	0	3

Prerequisite: Nil	Course Category: Program core course Course type: Integrated Course with Theory

Course Objectives:
To introduce the concept of Robotics and Industrial Automation for the development of a desirable product.

Course Outcomes:

CO1	Understand the functional elements of Robotics
CO2	To know about the basic concepts in industrial automation
CO3	To impart knowledge on the direct and inverse kinematics
CO4	To introduce the manipulator differential motion and control and to educate on various path planning technique.
CO5	To Know about the design of mechatronics systems

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	1	2	2	3	6	5	5	5	7	4	6	6	1,2	3,4,7	2,6
CO1	3	3	2	2	3		1		2		1	2	2		3
CO2	3	3	2	2					1						
CO3	3	3	2	3	3			2	2		1	2	2		3
CO4	3	3	3	3				2	1		1				
CO5	3	3	3	3			2	1	1		2	2	2		

Course Topics

UNIT I BASIC CONCEPTS OF ROBOTS

Brief history-Types of Robot–Technology-Robot classifications and specifications-Design and control issues- Various manipulators – Sensors - work cell - Programming languages.

UNIT II FUNDAMENTAL CONCEPTS OF INDUSTRIAL AUTOMATION

Fundamental concepts in manufacturing and automation, definition of automation, reasons for automating. Types of production and types of automation, automation strategies, levels of automation.

UNIT III DIRECT AND INVERSE KINEMATICS

Mathematical representation of Robots - Position and orientation – Homogeneous transformation- Various joints- Representation using the Denavit Hattenberg parameters -Degrees of freedom- Direct kinematics-Inverse kinematics- SCARA robots- Solvability – Solution methods-Closed form solution.

UNIT IV MANIPULATOR DIFFERENTIAL MOTION AND STATICS

Linear and angular velocities-Manipulator Jacobian-Prismatic and rotary joints–Inverse -Wrist and arm singularity - Static analysis - Force and moment Balance.

UNIT V DESIGN OF MECHATRONIC SYSTEMS

Stages in design, traditional and mechatronic design, possible design solutions. Case studies-pick and place robot, engine management system.

Practical:
Unit I
Study on basics of Robot
Introduction to degrees of freedom and classification of robots
Study on kinematics of robotic arm

Unit II:
Study on mobile robots
Determination of maximum and minimum position of links.
Verification of transformation (Position and orientation) with respect to gripper and world coordinate system

Unit III
Estimation of accuracy, repeatability and resolution
Robot programming and simulation for pick and place
Robot programming and simulation for Colour identification

Unit IV
Robot programming and simulation for Shape identification
Robot programming and simulation for machining (cutting, welding)
Robot programming and simulation for writing practice
Unit V
Robot programming and simulation for any industrial process (Packaging, Assembly)
Robot programming and simulation for multi process

Pick and place operation by robotic arm

Text Book:

1. R.K.Mittal and I.J.Nagrath, Robotics and Control, Tata McGraw Hill, New Delhi,4th Reprint, 2005.
2. JohnJ.Craig ,Introduction to Robotics Mechanics and Control, Third edition, Pearson Education, 2009.
3. M.P.Groover, M.Weiss, R.N. Nageland N. G.Odrej, Industrial Robotics, McGraw-Hill Singapore, 1996.

Reference(s):

1. Ashitava Ghoshal, Robotics-Fundamental Concepts and Analysis', Oxford University Press, Sixth impression, 2010.
2. Edwin Wise, Applied Robotics, Cengage Learning, 2003.
3. R.D.Klafter,T.A.Chimielewski and M.Negin, Robotic Engineering–An Integrated Approach, Prentice Hall of India, New Delhi, 1994.
4. B.K.Ghosh, Control in Robotics and Automation: Sensor Based Integration, Allied Publishers,Chennai, 1998.
5. S.Ghoshal, " Embedded Systems & Robotics" – Projects using the 8051 Microcontroller", Cengage Learning, 2009.

212MEC1304 -MANUFACTURING PROCESSES	L	T	P	X	C
	2	0	2	0	3

Prerequisite: Nil	Course Category: Program core course Course type: Integrated Course with Theory

Course Objectives:

To introduce the fundamentals of various manufacturing processes for the development of a desirable product with different shape, size and form.

Course Outcomes:

CO1	Interpret foundry practices like pattern, mold and core making.
CO2	Select appropriate joining processes to join the workpiece.
CO3	Differentiate various metal forming processes with suitable selection procedure.
CO4	Classify different high velocity forming, plastic molding and extrusion of plastic and thermoforming.
CO5	Enumerate the preparation strategies of the P/M workpiece.

Mapping of Course Outcomes:

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

Course Topics

Unit-I: METAL CASTING PROCESS

Moulding sands – types and properties – patterns – types, selection of patterns, pattern allowances – design of patterns – classifications of castings according to mould materials and moulding methods- forces acting on the molding flasks – short & long freezing range alloys – solidification and cooling – riser and gating design – design considerations – special casting techniques – fettling and finishing of castings – defects in castings.

Unit-II: FABRICATION PROCESS

Classification of welding process – principle of gas welding – arc welding – resistance welding – solid state welding – thermo-chemical welding – radiant energy welding – brazing and soldering – Heat affected zones in welding, Methods to minimize HAZ- thermal cutting of metals or alloys.

Unit-III: BULK DEFORMATION PROCESSES

Forging – classification of forging processes, forging defects and inspection – Rolling – classification of rolling processes, rolling mill, rolling of bars and shapes – Extrusion – classification of extrusion processes, extrusion equipments – Drawing process.

Unit-IV: FORMING PROCESS

Sheet metal forming - High velocity forming - explosive forming, electro hydraulic forming - magnetic pulse forming - pneumatic - mechanical high velocity forming. Plastic forming - Plastics - types of plastics – plastic moulding processes, defects in plastics, Thermoforming, laminating and reinforcing, foamed plastics.

Unit-V: POWDER METALLURGY

Introduction – process description – manufacture of metal powders – blending of powders – compacting – sintering – secondary operations – isostatic pressing – metal injection moulding – products of powder metallurgy – advantages, disadvantages and limitations.

List of Experiments:

1. Inspection of molding sand properties such as moisture test, grain fineness number test etc.
2. Create a mold (wood) of a specific product
3. Develop a casting component and perform spiral fluidity test
4. Preparation of 3D CAD drawing and performing casting simulation using Virtual Lab (http://efoundry.iitb.ac.in)
5. Preparation of weld groove, study the types of fillers and filler materials
6. Use two different welding electrodes in arc welding process and compare its weldability
7. Perform soldering process on a PCB
8. Choose appropriate flames in gas welding process for welding ferrous metals
9. Compare the hardness in weld metal, HAZ zone & parent metal. Also determine the welding strength.
10. Perform laser spot welding using Virtual Lab (http://mm-coep.vlabs.ac.in/LaserSpotWelding/Theory.html)
11. Study the tools used for forging, rolling, extrusion and drawing
12. Using machine drawing concept, draw an hexagonal nut/bolt in CAD
13. Produce the hexagonal nut/bolt by any forming process

14. Perform metal forming simulation using Virtual Lab (http://msvs-dei.vlabs.ac.in)

15. Apply Archimedes' principle to determine the density & porosity of a given sample

Text Book:

1. S.K.Hajra Choudhury, A.K.Hajra Choudhury and Nirjhar Roy, "*Elements of Workshop Technology, Vol: I Manufacturing Processes*", Edition: 16, Media Promoters, 2016.
2. R.K.Rajput, "*A Textbook of Manufacturing Technology: Manufacturing Processes*", Second Edition, Lakshmi Publications, 2017.

Reference(s):

1. R.K.Jain, "*Production Technology*", Edition: 19, Khanna Publisher, 2019.
2. P.Mikell Groover, "*Fundamentals of Modern Manufacturing: Materials, Processes, and Systems*", Edition: 7, Wiley, 2018.

212MEC1305 ENGINEERING THERMODYNAMICS	L	T	P	X	C
	3	0	0	3	4
Prerequisite: Nil	Course Category: Program core course Course type: Theory				

Course Objectives:

To apply the fundamentals of Thermodynamics upon the process and applications undergoing with respect to the gas power cycles, and refrigeration system

Course Outcomes:

CO1	Outline the fundamental concepts of law of thermodynamics
CO2	Evaluate the change in entropy and available energy.
CO3	Evaluate properties of pure substances and gas mixtures
CO4	Evaluate the performance of steam power cycles
CO5	Analyze air-conditioning processes using the principles of psychrometry.

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	1	2	2	3	6	5	5	5	7	4	6	6	1,2	3,4,7	2,6
CO1	3	3	1					1				1	3	2	
CO2	3	3	1					1				1	3	2	
CO3	3	3	1					1				1	3	2	
CO4	3	3						1				1	3	2	
CO5	3	3	1					1				2	3	2	

Course Topics

UNIT I: LAWS OF THERMODYNAMICS

Work – modes of work transfer, first Law for Cyclic & Non-cyclic processes; Concept of total energy E; First Law for Flow Processes - Derivation of general energy equation for a control volume, Applications of flow processes; Second law – Kelvin- Planck and Clausius statements. Comparison of Heat Engines- Refrigerator – Heat pumps; Definitions of thermal efficiency and

COP; Definition of reversible process; Internal and external irreversibility; Carnot cycle; Absolute temperature scale.

UNIT II: ENTROPY AND AVAILABILITY

Clausius Theorem – Entropy (S) is a property - Clausius inequality, Illustration of processes in T-S coordinates, Evaluation of S for solids, liquids, ideal gases. Principle of increase of entropy - Definition of Isentropic efficiency for compressors turbines and nozzles, Availability and Irreversibility – available energy in a cycle.

UNIT III: PURE SUBSTANCES

Definition of Pure substance, Ideal Gas Properties; Definitions of saturated states; P-V-T surface; Use of steam tables Saturation tables; Superheated tables; Identification of states & determination of properties, Mollier's chart.

UNIT IV: VAPOUR POWER CYCLE

Basic Rankine cycle, with superheat, reheat and regeneration comparison with Carnot cycle, Comparison of three cycles, discussion on advantages and disadvantages of reheat and regenerative cycles.

UNIT V: PSYCHROMETRY

Psychrometry - atmospheric air and psychrometric properties – dry bulb temperature, wet bulb temperature, dew point temperature, partial pressures, specific and relative humidity, enthalpy and adiabatic saturation temperature - construction and use of psychrometric chart - analysis of various processes- heating, cooling, dehumidifying and humidifying- adiabatic mixing of stream, summer and winter air-conditioning.

X component:

1. Energy calculation for cyclic process using Cycle Tempo / CyclePad / Comsol Multiphysics
2. Calculation of Work transfer in Compressor at polytropic process.
3. Energy conversion calculation in condenser and nozzle.
4. Comparing COP in Refrigerator and Heat Pump.
5. *Determination of Change in Entropy of Closed system.*
6. *Change in Entropy in open system - Cycle Tempo / CyclePad / Comsol Multiphysics.*
7. Cycle Tempo / CyclePad / Comsol Multiphysics – Superheated steam properties
8. Solving numerical problems using Python programming language
9. *Cycle Tempo / CyclePad / Comsol Multiphysics – Reheat in Rankine cycle*
10. Cycle Tempo / CyclePad / Comsol Multiphysics – Dry and Wet Bulb Temperature measurement

Competition:

Competition among the Peers at the end of the course based on themes introduced in the course. (Various themes can be selected based on faculty-student preference.
Ex. Clean water making device using thermal based concepts)

Text book:

1. Nag, P.K., Engineering Thermodynamics, Tata McGraw-Hill Co. Ltd., 2017
2. Y.A.Cengel, Thermodynamics – An Engineering Approach, Tata Mc Graw Hill, New delhi, Ninth edition, 2019

Reference book:

1. R.K. Rajput - Engineering Thermodynamics, Published by : Laxmi publications Private limited Eighth edition 2018
2. Holman J.P., Thermodynamics, McGraw-Hill, 3rd Edition, 1995
3. Arora C.P., Thermodynamics, Tata McGraw-Hill, New Delhi, 2003

212MEC1106 ENGINEERING MECHANICS	L	T	P	X	C
	3	0	0	0	3
Prerequisite: Nil	Course Category: Program core course Course type: Theory				

Course Objectives:

To gain knowledge about the concept of equilibrium in both statics and dynamics to analyse real time problems.

Course Outcomes:

CO1	Demonstrate the equilibrium conditions of particle and rigid body also apply the same for analysis of real time problems.
CO2	Develop models based on the basic principles for analysing various trusses and frames by using analytical and experimental methods.
CO3	Apply the concept of the friction and demonstrate the effects of friction between the surfaces.
CO4	Identify the centroid and moment of inertia of the composite shapes by using analytical and virtual methods.
CO5	Apply the concept of dynamics equilibrium and its equations in analysing the objects under both rectilinear and curvilinear motion.

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	**1**	**2**	**2**	**3**	**6**	**5**	**5**	**5**	**7**	**4**	**6**	**6**	**1,2**	**3,4,7**	**2,6**
CO1	3	3	2	2	2				2				3	3	2
CO2	3	2	2	2	3				2				3	3	2
CO3	3	2	3	3	2				2				3	3	
CO4	3	3	3	2	2				2				3	3	2
CO5	3	2	2	2	2				2				3	3	

Course Topics

UNIT I: STATICS OF PARTICLES AND RIGID BODIES

Six Fundamental principles and concepts - Force - System of Forces - Coplanar Concurrent Forces - Components in Space, Resultant of forces acting on the particle - Particle in equilibrium – concepts in 2 -D & 3-D – Equations of Equilibrium of Coplanar Systems and Spatial Systems.

Rigid Body - Moment of Forces and its Application - Couples and Resultant of Force System equilibrium in 2-D Supports and its reactions - Pin support - roller support.

UNIT II: ANALYSIS OF TRUSSES AND FRAMES

Basic Structural Analysis- Equilibrium in three dimensions - Method of Sections- Method of Joints- How to determine if a member is in tension or compression- Simple Trusses- Zero force members - Frames & Machines.

UNIT III: FRICTION

Types of friction, limiting friction, Laws of Friction, Static and Dynamic Friction - Motion of Bodies, simple contact friction, sliding block, wedge friction, rolling resistance – Rope and Belt friction.

UNIT IV: PROPERTIES OF SURFACES AND SOLIDS

Centroid of simple figures from first principle, centroid of composite sections - Centre of Gravity and its implications - Area moment of inertia - Definition, Moment of inertia of plane sections from first principles, Theorems of moment of inertia, Moment of inertia of standard sections - Mass moment inertia of circular plate, Cylinder, Cone, Sphere- Principal moment of inertia.

UNIT V: DYNAMICS

Review of particle dynamics - Displacements, velocity and acceleration, their relationship - Equations of motions - Rectilinear motion- Plane curvilinear motion - Newton's 2nd law- Impulse, momentum, impact - D'Alembert's principle and its applications in plane motion and connected bodies - Work energy principle and its application in plane motion of connected bodies - Virtual Work and Energy Method - Virtual displacements, principle of virtual work for particle and ideal system of rigid bodies.

Practical:

Unit 1

Determination of equilibrant acting on a point in a three-force system using Lami's theorem.
Determination of the equivalent force and its distance from the support.
Determination of the resultant of the parallel force system.

Unit 2

Analyse the deflection of the Pratt truss with supports on the end.
Analyse the deflection of the Warren truss with supports on the end.
Analyse the deflection of the Howe truss with supports on the end.

Unit 3

Determination of the coefficient of friction of the block using the experimental technique.
Analysis of the load acting on the Wedge for raising and lowering the load.

Unit 4

Determination of the centroid of the unknown shape.
Determination of MOI using the bell crank lever apparatus.

Unit 5

Determination of acceleration of the connected bodies of various loads.
Determination of range of projectiles by experimental methods.

Text Book(s):

1. F.P.Beer, and E.R.Johnson, “Vector Mechanics for Engineers – Statics and Dynamics”, Edition: 10, McGraw Hill , 2017.
2. J. L. Merriam, “Engineering Mechanics", Edition: 7, Wiley , 2017.

Reference(s):

1. H.Irving, Shames, “Engineering Mechanics, Statics and Dynamics”, Edition: 4, Prentice Hall of India Ltd , 2017.

212MEC2107 STRENGTH OF MATERIALS	L	T	P	X	C
	3	1	0	0	4
Prerequisite: Engineering Mechanics ()	Course Category: Program core course Course type: Theory				

Course Objectives:

To acquire knowledge in the basic concepts of stress, strain and deformation of solids and analyze the beam deflection, torsion in springs and shafts.

Course Outcomes:

CO1	Analyse the simple stresses in bars, composite bars, thermal stresses and strain energy.
CO2	Analyse the stresses in two dimensional bodies and evaluate the deformation in thin, thick cylinders and spherical shells.
CO3	Demonstrate shear force, bending moment and stress distribution of various types of beams with different support.
CO4	Analyzing the deflection of the beams through various methods.
CO5	Illustrate the deflection of all types of shafts due to torsion and deformation of various types of springs.

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	1	2	2	3	6	5	5	5	7	4	6	6	1,2	3,4,7	2,6
CO1	3	2	3	2	1								3		1
CO2	3	2	3	2	2								3		1
CO3	3	2	3	2	1								3		1
CO4	3	2	3	2	1								3		1
CO5	3	2	3		2								3		1

Course Topics

UNIT I: STRESS, STRAIN AND DEFORMATION IN SOLIDS

Stress - types – Hook's law – elastic constants and relationships between them – composite bars – thermal stresses - Strain Energy – Resilience – Gradually, suddenly, impact loadings

UNIT II: STRESS AND DEFORMATION IN TWO DIMENSIONAL BODIES

Two dimensional state of stress at a point – normal and shear stresses on any plane, principal planes and principal stresses – graphical method– Mohr's Circle - stresses and deformations in thin cylinders and spherical shells due to internal pressure

UNIT III: BEAMS AND SUPPORTS

Beam-types- cantilever, simply supported, overhanging beams. Types of loadings – shear force – bending moment diagram. Theories of bending – bending stress distribution – load carrying capacity for point and distributed loads. Shear stress distribution across various beam sections

UNIT IV: DEFLECTION IN BEAMS

Deflection in beams using double integral method – area moment method for computation of slopes and deflection in beams – Macaulays method - Conjugate beam method.

UNIT V: TORSION IN SPRINGS AND SHAFTS

Torsional stresses and deformation in solid shafts, hollow shafts– Helical springs- Open-Closed coil springs – leaf springs – stresses in springs – Torsion and deformation – deflections in spring.

X Component:

Projects to be undertaken by students in thematic areas identified after student-faculty discussion.

(Ex. Design - Small Scissor lift design, Thermal – solar plate structure, Robotics – Robotics arm, Machine – Pellet extruder, Entrainment – Rig animation or mini tripod design, or canopy design)

1. Concept selection
2. Material Selection
3. Free Body Diagram
4. *Shear Force Diagram*
5. *Stress calculation*
6. Selection of Beam
7. Bending Moment Diagram
8. Section properties
9. *Concept Design Analysis*
10. *Analysis load behaviour*
11. *Cost Analysis*
12. Visual representation of project / Real time model
13. Presentation

Text Book(s):

1. E.P Popov, "Engineering Mechanics of Solids", Edition: 2, Prentice Hall of India, New Delhi , 2015.

2. S.M.A Kazimi, "Solid Mechanics", Edition: 4, Tata McGraw Hill Book Co Ltd , 2017.

Reference(s):

1. R.K Rajput, "Strength of Materials", Edition: 6, S. Chand Publications, 2015.
2. R.K Bansal, "Strength of Materials", Edition: 6, Laxmi Publications, 2018.
3. R. Subramanian, "Strength of Materials", Edition: 3, Oxford University Press, 2016.

212MEC2208 **STRENGTH OF MATERIALS LABORATORY**	L	T	P	X	C
	0	0	2	0	1

Prerequisite:	Course Category: Program core courses Course type: Practical

Course Objectives:

To gain knowledge on various types of methodologies and experimentations to determine the mechanical properties of various engineering materials

Course Outcomes:

CO1	Determine the compression and hardness test on different materials.
CO2	Analyze the tension and double shear test with mild steel.
CO3	Apply the deflection test on various types of beams.
CO4	Analyse the impact test for different materials.
CO5	Determine the torsional characteristics for the given materials.

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	1	2	2	3	6	5	5	5	7	4	6	6	1,2	3,4,7	2,6
CO1			2		2	2							2	2	
CO2	2		1		1	2							2	1	
CO3	2		1	3							2		1	2	
CO4	3		2	3			2				2	2	2	2	
CO5	2		3	1	2								2	2	

List of Experiments:

Compression and hardness studies

- Compression test on wood

- Compression test on brick
- Brinell hardness test
- Vickers hardness test

Shear and tension studies

- Double shear test on mild steel
- Tension test on rolled TOR steel rod

Deflection studies

- Deflection test on simply supported steel beam (Central point load)
- Deflection test on simply supported steel beam (Two point load)
- Deflection test on simply supported wooden beam (Central point load)
- Deflection test on simply supported wooden beam (Two point load)

Impact studies

- Static bending test on wooden beam
- Impact test on timber (Charpy)

Torsion and springs

- Torsion test on mild steel wire
- Torsion test on mild steel rod
- Deflection test on open coiled and close coiled helical spring

Reference(s):

Strength of Materials Manual prepared by Kalasalingam Academy of Research and Education.

212MEC1109 FLUID MECHANICS & MACHINERY	L	T	P	X	C
	3	1	0	0	4

Prerequisite:	Course Category: Program core course Course type: Theory

Course Objectives:

To understand the basic principles of fluid mechanics and to identify fluid characteristics, boundary layer concepts and flow through pipes. To understand/evaluate the performance of turbines and pumps through characteristic curves.

Course Outcomes:

CO1	Apply the basic concepts to the real time problems on pressure measurement and Buoyancy
CO2	Interpret the kinematics and dynamics of fluid flow and apply Bernoulli's equation to real time problems.
CO3	Calculate and Analyze the different types of losses occurs in a pipe flow
CO4	Contrast the working principle of different turbines and analyze the performance of different turbines
CO5	Select a pump based on application and explain the working principles of different pumps and calculate the performance of various pumps

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	1	2	2	3	6	5	5	5	7	4	6	6	1,2	3,4,7	2,6
CO1	3	2		2									2	2	2
CO2	3	3	2	3	2								3	3	2
CO3	3	3	2	3	3								3	3	2
CO4	3	3	3	2	2								3	2	
CO5	3	3	3	2	2								3	2	

Course Topics

UNIT I: BASIC CONCEPTS AND PROPERTIES

Fluid–definition, properties of fluids-density, specific weight, specific volume, specific gravity, temperature, viscosity, compressibility, vapour pressure - fluid statics-concept of fluid static pressure, absolute and gauge pressures-pressure measurements by manometers and Mechanical Gauges. Buoyancy concepts: buoyancy, stability of immersed and floating bodies, Centre of Buoyancy, Metacentre–Determination of Metacentric Height

UNIT II: FLUID KINEMATICS AND FLUID DYNAMICS

Fluid kinematics - flow visualization, lines of flow, types of flow, velocity field and acceleration, continuity equation(one and three dimensional differential forms)-equation of streamline, stream function, velocity potential function, circulation, flow net, fluid dynamics-equations of motion, Euler's equation along a streamline, Bernoulli's equation, applications - Venturimeter, Orifice meter, Pitot tube , Flow measurement using rotameter - dimensional analysis - Buckingham's π theorem applications-similarity laws and models.

UNIT III: INCOMPRESSIBLE FLUID FLOW

Viscous flow-Navier-Stokes equation(Statement only) -shear stress, pressure gradient relationship, Couette flow- laminar flow between parallel plates, Laminar flow through circular tubes (Hagen Poiseulle's) - flow through pipes - Darcy - Weisbach's equation, Moody’s diagram- friction factor minor losses– flow through pipes in series and in parallel –boundary layer flows, boundary layer thickness, boundary layer separation, measures of boundary layer thickness, Lift and drag on immersed bodies

UNIT IV: HYDRAULIC TURBINES

Fluid Machines-definition and classification-exchange energy-Euler's Equation for turbomachines- construction of velocity vector diagrams- head and specific work – components of energy transfer-degree of reaction. Hydro turbines-definition and classifications- Pelton wheel, Francis turbine, propeller turbine, Kaplan turbine–working principles-velocity triangles, workdone, specific speed, efficiencies, performance curve for turbines.

UNIT V: HYDRAULIC PUMPS

Pumps- definition and classifications - Centrifugal pump - classifications, working principle, velocity triangles, specific speed, efficiency and performance curves - reciprocating pump classification, working principle, indicator diagram, work saved by air vessels and performance curves - cavitations in pumps - rotary pumps - working principles of gear pump, vane pump, Lobe pump and piston pump, performance of positive displacement pump.

X Component:

1. Buoyancy of floating cube
2. Measurement of pressure using simple U-tube, inclined U-tube and piezometer
3. Measurement of fluid density, specific weight, specific volume, specific gravity of water, oil and mercury
4. *Experiments in Bernoulli's equation and pipe flow*
5. *Fluid flow analysis using ANSYS FLUENT*
6. *Fluid Flow analysis through Venturimeter and orifice meter using Ansys Fluent*
7. Experiment on Couette flow
8. Boundary layer flow between two parallel plates
9. Frictional pressure drop in pipe
10. *Design and analysis of turbine characteristic curve using CF Turbo*
11. Design and analysis of pump characteristic curve using CF Turbo

Text Book(s):

1. Streeter, V.L., Wylie, E.B., and Bedford K.W., Fluid Mechanics, McGraw-Hill, 9th Edition, 2010.
2. Bansal, R.K., A Textbook of Fluid Mechanics and Hydraulics Machines, Laxmi publications (P) Ltd, New Delhi, 10th edition,2019.

Reference(s):

1. Kumar, K.L., Engineering Fluid Mechanics, S Chand Publishing, 2016
2. Ramamrutham, S., Hydraulics Fluid Mechanics and Fluid Machines, DhanpatRai and Sons, Delhi, 2011 edition, 2020 Reprint
3. Cengel Y.A., Cimbala, J.M., Fluid Mechanics; Fundamentals and Applications, McGrawHill, 4th edition, 201

212MEC1210 **FLUID MECHANICS AND MACHINERY LABORATORY**	L	T	P	X	C
	0	0	2	0	1
Prerequisite:	Course Category: Program core courses Course type: Practical Course				

Course Objectives:

To gain knowledge on basic concepts of fluid statics, fluid dynamics and fluid kinematics and to study the performance characteristics of hydraulic turbines and pumps

Course Outcomes:

CO1	Determine viscosity through different viscometers
CO2	Analyze the coefficient of discharge in the orifice meter, venturi meter and rotameter.
CO3	Visualize the flow net and verify the bernoulli's equation
CO4	Determine the losses in flow through pipes
CO5	Plot and analyze the performance characteristic curves of turbines and pumps

Mapping of Course Outcomes:

PO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
ASO	**1**	**2**	**2**	**3**	**6**	**5**	**5**	**5**	**7**	**4**	**6**	**6**	**1,2**	**3,4,7**	**2,6**
CO1			2			2							2	2	
CO2	1				2	2							2	2	
CO3	2		2	1							2		2	2	
CO4	3		2	3			2				2	2	2	2	
CO5	2		3	1	2								2	2	

List of Experiments:

Viscosity

- Determination of Kinematic Viscosity of fluid at different temperatures using Redwood Viscometer
- Determination of Viscosity of fluid using Saybolt Viscometer

Coefficient of discharge

- Determination of Rate of Flow using Rotameter
- Determination of the Coefficient of discharge of a given Venturimeter.
- Determination of the Coefficient of discharge of a given Orifice meter.

Flow net and Bernoulli's Equation

- Visualization of formation of Flownet for a given set of stream function Equipotential function
- Verification of Bernoulli's Theorem

Losses in pipes

- Determination of friction factor of the given pipe
- To study minor losses of flow through pipe

Hydraulic machinery

- Conducting experiments and drawing the characteristic curves of the Pelton wheel.
- Conducting experiments and drawing the characteristics curves of Francis turbine.
- Conducting experiments and drawing the characteristic Kaplan turbine
- Conducting experiments and drawing the characteristic curves of Centrifugal pump
- Conducting experiments and drawing the characteristic curves of reciprocating pumps.
- Conducting experiments and drawing the characteristic curves of Gear pump.

Reference(s):

- Fluid Mechanics and Machinery Manual prepared by Kalasalingam Academy of Research and Education.

212MEC1111 **MATERIALS SCIENCE AND ENGINEERING**	L	T	P	X	C
	3	0	0	0	3
Prerequisite: Nil	Course Category: Program core course Course type: Theory				

Course Objectives:

To impart fundamental ideas about the constituents of engineering materials and their strengthening mechanisms along with their characterization methods.

Course Outcomes:

CO1	Identify the atomic structure and properties of the materials
CO2	Categorize the various phases in metal alloys
CO3	Identify and select the appropriate heat treatment method to strengthen alloys
CO4	Identify the appropriate applications based on the knowledge on materials properties
CO5	Choose the suitable mechanical testing and methods to evaluate the materials characteristics

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	1	2	2	3	6	5	5	5	7	4	6	6	1,2	3,4,7	2,6
CO1	3	2	1	2									3	1	
CO2	3		2	3									3	3	
CO3	3	2	1	2									3		
CO4	3	2	2	3									3	2	
CO5	3	3	2										3	3	

Course Topics

UNIT I: BASICS

Types of bonds in crystal structure: ionic, metallic, covalent and Van Der Waals bonding with examples. Crystal structures: type of crystal structures, bravais lattice - miller indices, atomic packing factor and APF for different crystal structures. Defects: types of defects, defects in atomic scale, one dimensional defects, surface defects indicating slip and twin in the microstructure. Mechanical behaviour of materials: mechanism of plastic deformation, slip, twinning, stacking faults, deformation bands and strain hardening

UNIT II: CONSTITUTION OF ALLOYS

Solid solution: solid solutions - substitutional and interstitial. Constitution of alloys: phase diagrams, isomorphous, eutectic, peritectic, eutectoid and peritectic reactions, iron – iron carbide equilibrium diagram – binary alloys. classification of steel and cast iron – microstructure, properties, and applications

UNIT III: HEAT TREATMENT

Annealing - full annealing, stress relief, recrystallisation and spheroidizing – normalizing - hardening and tempering of steel - isothermal transformation diagrams – cooling curves superimposed on I.T. diagram - hardenability, jominy end quench test – austempering, martempering – case hardening - carburising, nitriding, cyaniding, carbonitriding – flame and induction hardening.

UNIT IV: METALS AND ALLOYS

Mechanical properties and applications - Nickel and nickel alloys, Copper and copper alloys, aluminum and alloys – polymers – synthesis and properties, ceramics – size dependence of properties – chemical, optical, vibrational, thermal, electrical, magnetic and mechanical properties of materials.

UNIT V: MECHANICAL TESTING AND CHARACTERISATION METHODS

Mechanical testing of materials for various types of loads – types of fracture – hardness tests (Brinell, Vickers and Rockwell), impact test- Izod and Charpy – fatigue and creep test. tribological properties of metals and non-metals – advanced characterization techniques - electron imaging of materials (SEM and TEM), techniques and applications of Scanning Probe Microscopies – principle and use of spectroscopies

X Component

1. Sample preparation following ASTM standard procedure for metallurgical polishing and etching for microstructure analysis.

2. Identification of different phases in metals and alloys through microstructural analysis.
3. *Phase change analysis on different weldments. Samples are steel with steel, steel with copper, steel with nickel.*
4. *Identification of different phases on paraffin with different nano – reinforcements.*
5. Bulk heat treatment and quenching of metals in different mediums (water, oil, salt and in air) for hardness measurement.
6. Surface modifications and hardness measurements on metals using weld cladding
7. Electrochemical corrosion and / or wear study on clad samples.
8. *Develop composite materials through moulding processes*
9. *Develop metals / MMC through casting (Stir / Centrifugal / Powder compaction)*
10. Selection of suitable mechanical testing techniques to evaluate the quality of the materials developed.
11. Selection of suitable metallurgical characterisation techniques to evaluate the quality of the materials developed.

Text Book

1. Material Science and Engineering William D Callister Jr, John Wiley and Sons, 10th Edition, Singapore, 2018
2. Engineering Materials, Kenneth G. Budinski and Michael K.Budinski Prentice-Hall of India Private Limited, 9th Indian Reprint 2009

Reference Book

1. Introduction to Physical Metallurgy, Sydney H.Avner, McGraw Hill Book Company, New York, 2017
2. Material Science and Engineering; Raghavan, V, Prentice Hall of India Pvt., Ltd., New Delhi, 2015

212MEC1312 **PARTIAL DIFFERENTIAL EQUATIONS, FOURIER TRANSFORM AND NUMERICAL METHODS FOR MECHANICAL ENGINEERS**	L	T	P	X	C
	2	0	2	0	3

Prerequisite: NA	Course Category: Program core courses Course type: Integrated Course with Theory

Course Objectives:

To understand the concepts of partial differential equations, fourier transforms and to find derivative and integrals using numerical methods

Course Outcomes:

CO1	Be able to perform basic computations related to fourier, sine and cosine transforms
CO2	Understand the different types of partial differential equations and the methods to solve them
CO3	Use partial differential equations to relate to string theory and heat transfer problems
CO4	Be able to realize and perform different numerical methods to find solutions to systems of linear equations
CO5	Be able to realize and perform different numerical methods to determine the derivative and integral of functions

Mapping of Course Outcomes:

PO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
ASO	**1**	**2**	**2**	**3**	**6**	**5**	**5**	**5**	**7**	**4**	**6**	**6**	**1,2**	**3,4,7**	**2,6**
CO1	1	1			3					2			1		1
CO2	2	1			3					2					1
CO3	3	1			3					2			3		1
CO4	3	1			3					2			1		1
CO5	3	1			3					2			1		1

Course Topics

UNIT I: FOURIER SERIES

Fourier series – Half range sine and cosine series - Fourier integral theorem (without proof) - Fourier transform pair - Sine and Cosine transforms – Properties - Transforms of simple functions – Convolution theorem - Parseval's Identity

UNIT II: PARTIAL DIFFERENTIAL EQUATIONS

First order partial differential equations, solutions of first order linear and nonlinear PDEs. Solution to homogeneous and nonhomogeneous linear partial differential equations second and higher order by complementary function and particular integral method.

UNIT III: APPLICATIONS OF PARTIAL DIFFERENTIAL EQUATIONS

Flows, vibrations and diffusions, second-order linear equations and their classification, Initial and boundary conditions, solution of the wave equation and diffusion equation by the method of separation of variables, The Laplacian in plane, cylindrical and spherical polar coordinates and solutions.

UNIT IV: SOLVING SYSTEM OF EQUATIONS

Errors in Numerical Computation - Iteration method – Regula Falsi Method - Newton-Raphson Method - Simultaneous Equations-Back Substitution Gauss Elimination Method-Gauss' Jordan Elimination Method-Iterative methods- Gauss Jacobi Iteration Method – Gauss–Seidel Iteration Method.

UNIT V: DIFFERENCE OPERATORS AND APPLICATIONS

Difference Operators - Forward difference Table- Properties of the Operator - Backward Differences – Central Difference Operator. Derivatives using Newton's forward Difference Formula and Newton's Backward Difference Formula – Derivatives using Central Difference Formulae. Numerical Integration - Newton – Cotes quadrature formula – Trapezoidal rule – Simpson's one third rule – Simpson's three eight rule

Practical:

Unit I

Fourier series
Sine and Cosine transforms
Convolution theorem

Unit II

Partial derivative of polynomials with two variables
Homogeneous and nonhomogeneous linear partial differential equations
Solution of higher order partial differential functions

Unit III

Classification of partial differential equations
Solution of wave equation, Solution of heat equations

Unit IV

Newton Raphson
Regula Falsi method
Gauss Elimination
Gauss Jordan method
Gauss Jacobi

Unit V

Newton's forward Difference Formula and Backward Difference
Trapezoidal rule
Simpson's one third rule
Simpson's three eight rule

Text Book(s):

1. Veerarajan T., Transforms and Partial Differential Equations, Third Edition, McGraw-Hill Education (India) Pvt. Ltd., 2016.
2. S.Arumugam, A.Thangapandi Isaac, and A. Somasundaram, Numerical Methods, Scitech Publications Pvt.Ltd., 2015.

Reference(s):

1. Kreyszig, E, Advanced Engineering Mathematics, John Wiley and Sons (Asia) Limited, Singapore , 10th Edn., 2016.
2. Grewal, B.S., Grewal, J.S., Higher Engineering Mathematics, Khanna Publishers, New Delhi, 45th Edition, 2018.
3. S.S. Sastry, Introduction Methods of Numerical Analysis, Prentice Hall of India Pvt. Ltd., 2012.

212MEC2313 **MACHINING AND MACHINE TOOL**	L	T	P	X	C
	3	0	2	0	4
Prerequisite: Manufacturing Processes (MEC21RXXX)	Course Category: Program core course Course type: Integrated Course- Theory				

Course Objectives:

To disseminate the concept of machining and manufacturing to the undergraduate students which includes various mechanisms of metal cutting, tooling, CNCs and its design considerations, and some recent advancements in machining techniques.

Course Outcomes:

CO1	Summarize the principles and mechanisms of metal cutting practice.
CO2	Identify the tooling materials for various machining operations.
CO3	Make use of CNC machines and its programming for milling and turning operations
CO4	Design the various components of CNC and its drives
CO5	Select a suitable advanced machining process for a variety of industrial applications.

Mapping of Course Outcomes:

PO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
ASO	**1**	**2**	**2**	**3**	**6**	**5**	**5**	**5**	**7**	**4**	**6**	**6**	**1,2**	**3,4,7**	**2,6**
CO1	3	2											3		
CO2	3	3	3	2									2	2	
CO3			3	3	3				3		2		3	3	3
CO4	3	2	3										3	2	3
CO5	2	3	1	3	3								2	3	

Course Topics

UNIT I: MECHANISM OF METAL CUTTING
General principles – chip formation – shear plane – cutting ratio – shear angle –shear strain - (force relations (orthogonal and oblique) – force system in orthogonal (merchant circle diagram) – thermal aspects of machining – tool wear and tool life.

UNIT II: CUTTING TOOLS AND MACHINING
Cutting tool materials – types of tools (single / multi) - turning, various lathe operations – milling – various milling operations – design of lathe structures (bed, column, housing, base, table).

UNIT III: CNC TURNING AND MILLING
Introduction – historical background – anatomy of CNC turning and milling. CNC part programming manual part programming – computer assisted part programming.

UNIT IV: DESIGN CONSIDERATIONS OF CNC
Design of slider and slide ways – ball bearing – selection of variable drives – selection of stepper motor – design of ball screw – selection of transducer.

UNIT V: ADVANCED MACHINING PROCESS
Chemical machining – electro chemical machining – wire EDM –laser beam machining – EBM – plasma arc machining – hard turning and high speed machining.

Practical:

Unit 1
Plain turning and Taper turning
External Thread Cutting
Thermal Effects of machining

Unit 2
Contour milling using vertical milling machine
Spur gear cutting in milling machine

Unit 3
Code and execute a suitable CNC program for milling
Code and execute a suitable CNC program for turning

Unit 4
Survey of items (threads, bearings, housing etc) required for the fabrication of table top CNC machine

Unit 5

Determine machinability of various materials in Abrasive water jet machining

X component:

1. Determination of the cutting force using lathe tool dynamometer during various operations
2. *Modelling of lathe structures*
3. Compile a CNC program for machining a product as prescribed and machine the same.
4. *Fabrication of tabletop CNC machine*
5. Experimentation of EDM and abrasive water jet machining

Text Book

1. Serope Kalpakjian and Steven R. Schmid, Manufacturing Engineering & Technology, Pearson Education, 2019.
2. M.C. Shaw , Metal cutting Principles, Edition: 2, Oxford clarendon Press , 2005.

Reference Book

1. R. C. S. Mehta N. S. Gaira, Basic Manufacturing Process (Theory and Practice), 2017, AirWalk Publications.
2. P C Sharma, A Textbook of Production Engineering, S Chand Publications, Reprint 2019.

212MEC3114 DESIGN OF MACHINE ELEMENTS	L	T	P	X	C
	2	1	0	0	3
Prerequisite: Strength of Materials (MEC21RXXX)	Course Category: Program core course Course type: Theory				

Course Objectives:

To introduce design procedures, industrial standards and theories of failure leading to machine component design as solutions for complex problems

Course Outcomes:

CO1	Solve simple stresses and theories of failures in machine components
CO2	Design shafts, keys and couplings for power transmission
CO3	Estimate the load carrying capacity of threads and welds joints
CO4	Design springs for different automotive and machine components
CO5	Analyze the pressure distribution and design journal bearing

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	1	2	2	3	6	5	5	5	7	4	6	6	1,2	3,4,7	2,6
CO1	3	3	2	1		1				1			2	2	1
CO2	3	3	3	1		1				1			2	3	1
CO3	3	3	2	1		1				1			2	2	1
CO4	3	3	3	1		1				1			2	2	1
CO5	3	3	2	1		1				1			2	2	1

Course Topics

UNIT 1: STRESS ANALYSIS AND THEORIES OF FAILURES

Basics in Engineering Design – standard size, preferred numbers, fits and tolerances – Types of simple stresses – static and varying loading – combined loading – theories of failures – allowable stress – factor of safety – stress concentration factor – fluctuating stress- design for combined fatigue loading Soderberg, Goodman and Gerber relations

UNIT 2: DESIGN OF COUPLINGS AND SHAFTS

Design principles of shafts – static, fatigue loading – critical speed. Design of keys. Design of couplings – flexible couplings and Rigid Couplings.

UNIT 3: DESIGN OF TEMPORARY AND PERMANENT JOINTS

Welded joints: Types of welded joints- weld symbols, strength of welds- centrally loaded joints-axially loaded joints-eccentrically loaded joints. Threaded joints: I.S.O. Metric screw threads-threaded joints in tension fluctuating load- torque requirement for tightening and eccentrically loaded bolted joints.

UNIT 4: DESIGN OF SPRINGS

Helical springs and leaf springs: Stresses and deflection in helical springs. Design of leaf springs-stress and deflection - exercise problems in springs used for automobiles

UNIT 5: DESIGN OF BEARINGS

Sliding contact bearings: Theory of lubrication- hydrodynamic bearings-Sommer field number-design of hydrodynamic bearings. Rolling contact bearings: Static and dynamic load capacity-cubic mean load- variable load-probability of survival- selection of deep groove and angular contact ball bearings.

Text Book(s):

1. V. Bhandari, "Design of Machine Elements", Edition: 5, Tata McGraw-Hill Book Co , 2020.
2. Joseph Shigley, Charles Mischke,Richard Budynas and Keith Nisbett, "Mechanical Engineering Design", Edition: 11, Tata McGraw-Hill , 2021.

Reference(s):

1. "Design Data book", Edition: 4, PSG College of Technology, Coimbatore , 2019.
2. T.V.Sundararajamoorthy, N.Shanmugam, "Machine Design", Anuradha Publications, 2018.
3. C. Robert Juvinall and M. Kurt Marshek, "Fundamentals of Machine Design", Edition: 7, Wiley, 2019.

212MEC2315 THEORY OF MACHINES		L	T	P	X	C
		2	1	2	0	4
Prerequisite:	Course Category: Program core course Course type: Integrated Course- Theory					

Course Objectives:

To understand the velocity and acceleration analysis of basic mechanisms and to familiarize with the process of balancing, analysis of vibrations

Course Outcomes:

CO1	Ability to apply the knowledge of simple mechanisms in real time applications by fabricating it.
CO2	Create and analyze the velocity and acceleration of various mechanisms by applying relative principle
CO3	Design, develop and analyze the profile of CAM for any applications.
CO4	Apply the concept of balancing and use it for reducing the unbalanced forces in rotating masses and reciprocating engines
CO5	Apply various principles of vibrations of different systems to minimize vibrations and Calculating gyroscopic couple on various vehicles

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	**1**	**2**	**2**	**3**	**6**	**5**	**5**	**5**	**7**	**4**	**6**	**6**	**1,2**	**3,4,7**	**2,6**
CO1	3	3	3				2		2	2		1	2	3	
CO2	3	2	3	2	2				1	1		1	2	3	1
CO3	3	3	3	3	2		2		2	2		1	2	3	
CO4	3	2	2	2	2	1		1				1	2	3	1
CO5	3	3	3	3	3			2		2		1	2	3	

Course Topics

UNIT I: BASICS OF MECHANISMS

Classification of mechanisms- Basic kinematic concepts and definitions- Degree of freedom, mobility- Grashof's law, Kutzbach criterion, Gruebler's criterion, Kinematic inversions of four bar chain and slider crank chains- Limit positions- Mechanical advantage- Transmission angle- Description of some common mechanisms, straight line generators-Indexing Mechanisms, Steering gear mechanisms such as Davis and Ackermann Steering gear.

UNIT II: KINEMATICS

Displacement, velocity and acceleration analysis of simple mechanisms, graphical velocity analysis using instantaneous centers - slider crank mechanism dynamics Coincident points- Coriolis component of acceleration- introduction to linkage synthesis three position graphical synthesis for motion and path generation-Virtual work principles for simple mechanism.

UNIT III: CAM PROFILES AND GEAR

Classifications - Displacement diagrams - Parabolic, Simple harmonic and Cycloidal motions - Graphical construction of displacement diagrams and layout of plate cam profiles - circular arc and tangent cams. Classification of gears - Gear tooth terminology - Fundamental Law of toothed gearing and involute gearing - Length of path of contact and contact ratio

UNIT IV: BALANCING OF MACHINES AND GOVERNOR

Static and dynamic balancing - balancing of rotating masses - balancing a single cylinder engine, balancing of multi cylinder engines. Governors Types Centrifugal governors Gravity controlled and spring controlled centrifugal governors Characteristics Effect of friction.

UNIT V: VIBRATION AND CONTROL MECHANISM

Basic features of vibratory systems - Basic elements and lumping of parameters - Degrees of freedom – Single degree of freedom - Free vibration - Equations of motion - natural frequency - Types of Damping -critical speeds of shaft - Gyroscopes -Gyroscopic couple - Gyroscopic stabilization - Gyroscopic effects in aeroplanes and ships

Practical:

Unit 1
Links, degree of freedom, pair - Shaper, Slotter, Planing machine mechanism
Davis and Ackermann Steering gear

Unit 2
Analysis of single slider crank mechanism using Mechanalyzer

Unit 3
Lathe gearbox - Measurement and representation through modelling (freehand sketch)
Determination of critical speed of cam

Unit 4
Determination of speed and sensitivity of a Porter governor
Determination of speed and sensitivity of a Proell governor
Determination of speed and sensitivity of a Hartnell governor

Unit 5
Determination of Natural Frequency of Transverse Vibration of a Free-Free Beam
Determination of Critical Speed of a Shaft using Whirling Apparatus
Determination Time period oscillation of simple pendulum

X – Component
1. Design and development of four bar mechanism using linkage software
2. Design and development of a single slider mechanism using linkage software
3. Design and simulation of indexing mechanism
4. *Analysis of 4-bar chain mechanism using MechAnalyzer*
5. *Analysis of double slider crank mechanism using MechAnalyzer*
6. Modelling of lathe gearbox assembly using NX cad
7. Simulation and contact stress analysis of lathe gearbox assembly
8. *Balancing of multiple mass in multiple plane*
9. *Design and simulation of mechanical governors*
10. Vibrations analysis of cantilever beams with various materials using single axis accelerometer, DAQ and Dewesoft

Text Book(s):
1. S.S Rattan, “Theory of Machines”, Edition: 4, Tata McGraw-Hill Publishing Company Ltd , 2017.
2. A. Ghosh and A. K. Mallik, “Theory of Mechanism, and Machines”, 3rd Ed., East West Press Pvt Ltd, 2009

Reference(s):
1. W.L Cleghorn, “Mechanisms of Machines”, Edition: 2, Oxford University Press, 2005.
2. L. Robert Norton, “Kinematics and Dynamics of Machinery”, Edition: 1, Tata McGrawHill , 2009.
3. Bansal Dr.R.K. “ Theory of Machines” Laxmi Publications (P) Ltd., New Delhi 2001.

212MEC3416 FINITE ELEMENT ANALYSIS	L	T	P	X	C
	2	0	2	3	4

Prerequisite: Nil	Course Category: Program core course Course type: Integrated Course- Practical

Course Objectives:

To gain knowledge about basic principles of finite element analysis procedure and apply the finite element principles into structural, thermal, and dynamic problems.

Course Outcomes:

CO1	Solve structural problems by formulating governing equations and boundary conditions
CO2	Relate the concept of one dimensional problems to solid mechanics and heat transfer applications.
CO3	Apply the two dimensional equations to applications such as plane stress & strain, plate and shell etc.
CO4	Perform numerical analysis and simulation of iso-parametric structures.
CO5	Examine the finite element concept to various vibrations and torsional applications.

Mapping of Course Outcomes:

PO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
ASO	**1**	**2**	**2**	**3**	**6**	**5**	**5**	**5**	**7**	**4**	**6**	**6**	**1,2**	**3,4,7**	**2,6**
CO1	3	3	3	2	2				2			1	3	1	1
CO2	3	3	3	2	3				2			2	3	1	1
CO3	3	3	2	2	3				2			2	3	1	1
CO4	3	3	2	2	3				2			2	3	1	1
CO5	3	3	2	2	3				2			1	3	1	1

Course Topics

UNIT I: INTRODUCTION

Historical Background, Mathematical modelling of field problems in engineering, governing equations, discrete and continuous models, boundary and Eigenvalue problems, Weighted Residual Methods, Variational formulation of boundary value problems, Ritz technique, Basic concept of Finite Element Method.

UNIT II: ONE DIMENSIONAL PROBLEMS

One dimensional second order equation, discretization, linear and higher order elements, derivation of shape functions, Stiffness matrix and force vectors, assembly of elemental matrices, solution of problems from solid mechanics and heat transfer.

UNIT III: TWO DIMENSIONAL PROBLEMS

Two dimensional equations, variational formulation, finite element formulation, triaelements-shape functions, elemental matrices and RHS vectors; application to thermal problems, Plane stresses and plane strain problems, body forces and thermal loads, plate and shell elements.

UNIT IV: ISOPARAMETRIC ELEMENTS FORMULATION

Natural coordinate systems, isoparametric elements and shape functions, numerical integration and application to plane stress problems, matrix solution techniques, solution of dynamic problems, and introduction to FE software using commercial finite element packages like Abaqus and Hypermesh.

UNIT V: VIBRATION AND TORSION PROBLEMS

Longitudinal vibration and mode shapes, fourth order beam equation, transverse deflections and natural frequencies, Torsion of non-circular shafts, quadrilateral and higher order elements

Practical:

UNIT 1:
Analysis of Cantilever beams
Analysis of simply supported and Fixed end beams (Different loading conditions)

UNIT 2:
Analysis the static deflection and Von Mises stress of one-dimensional element
Heat transfer analysis of chimney

UNIT 3
Stress Analysis of a rectangular plate with a circular hole.
Composites laminated plate analysis using Shell Element
Analysis of 2D-heat sink

UNIT 4:
Numerical integration of discrete experimental data in mat lab.
Plane stress / Plane strain analysis

UNIT 5
Determination of Natural Frequency of Free-Free Beam.
Mode frequency analysis of beams.

X- Component.

1. Workbench 3D analysis of cantilever and fixed beam with different Channel section
2. *Analysis of one dimensional frame / truss structure using ANSYS.*
3. Analysis of heat transfer in Vehicle Silencers.
4. Railway beam under the influence of thermal stresses.
5. *Analysis of crane hooks using ANSYS workbench.*
6. *Buckling analysis of column structures.*
7. Harmonic Analysis of suspension spring
8. Natural frequency and damping analysis of hollow shaft

Text Book(s):
1. J.N Reddy, An Introduction to Finite Element Method, Edition: 4, Tata McGraw Hill, 2020.
2. P. Seshu, Text Book of Finite Element Analysis, Edition: 2, Prentice Hall, 2013.

Reference(s):
1. S.S.Rao, The Finite Element Method in Engineering, Ed :5, Butterworth Heinemann, 2010.
2. Klaus-Jurgen Bathe, “Finite Element Procedure” Edition: 2, Prentice Hall, Pearson Education, Inc, 2016, ISBN 978-0-9790049-5-7.
2. Chandraputla & Belegundu, Introduction to Finite Elements in Engineering, Edition: 4, Pearson Education India, 2015.

212MEC2317 THERMAL ENGINEERING		L	T	P	X	C
		2	1	2	0	4
Prerequisite: Thermodynamics (MEC21RXXX)	Course Category:Program core course Course type: Integrated Course-Theory					

Course Objectives:

To understand dynamics involved in thermal energy transformation and to apply thermodynamics laws upon gas power cycles followed by performance analysis of reciprocating ideal air compressor

Course Outcomes:

CO1	Outline the fundamental concepts of gas power cycles
CO2	Enumerate the implications of Internal combustion Engine
CO3	Employ the basic concepts behind steam nozzles and turbines
CO4	Analyse and acquire solutions to the problems involved in the air compressors
CO5	Apply the basics of thermodynamics on Refrigeration

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	1	2	2	3	6	5	5	5	7	4	6	6	1,2	3,4,7	2,6
CO1	3	3						1				1	3	2	
CO2	3	3						1				1	3	2	
CO3	3	3						1				1	3	2	
CO4	3	3						1				1	3	2	
CO5	3	3						1				1	3	2	

Course Topics

UNIT I: GAS POWER CYCLES

Air standard Otto, Diesel and Dual cycles -Air standard Brayton cycle –Calculation of mean effective pressure and air standard efficiency, effect of reheat, regeneration and intercooling.

UNIT II: ENGINE AUXILIARY SYSTEMS

Engine Components - Working principles and types of carburetors, ignition systems, fuel pumps and injectors, MPFI, CRDI, lubricating and cooling systems; Super and turbocharging. Hybrid and Electric engines.

UNIT III: NOZZLES, DIFFUSER AND TURBINES

Flow of steam through nozzles & Shape of nozzles - Effect of friction - Critical pressure ratio – Supersaturated flow - Steam turbine – Impulse and Reaction principles - Compounding, velocity diagrams for simple and multistage turbines.

UNIT IV: AIR COMPRESSOR

Reciprocating compressors, Effect of clearance and volumetric efficiency. Adiabatic, Isothermal and Mechanical efficiencies, staging of reciprocating compressors, optimal stage pressure ratio, effect of intercooling, minimum work for multistage reciprocating compressors

UNIT V: REFRIGERATION

Reversed Carnot cycle, Reversed Brayton cycle - Refrigerating effect -Power required, Unit of refrigeration, COP - Refrigerants and their desirable properties; Vapor compression refrigeration system - Vapor absorption refrigeration system.

Practical:

Unit 1

Performance test on four stroke diesel engines

Unit 2

Port timing diagram of Two stroke Engine
Valve timing diagram of four stroke diesel engine

Unit 3

Effect of heterogeneous steam flow through nozzles

Unit 4

Performance test on single stage air compressor
Performance test on two stage air compressors

Unit 5

Calculate the viscosity of lubricating oil using open and closed cup apparatus.
Determine the flash and fire point for kerosene and diesel.

Text Book(s):

1. R. K. Rajput, “Thermal Engineering”, Edition: 8, Laxmi Publication, 2010.
2. M. Mahesh Rathore, “Thermal Engineering”, Edition: 1, Mcgraw Higher ed, 2012

Reference(s):

1. John B. Heywood, "Internal Combustion Engine Fundamentals", 2nd Edition, McGraw-Hill Education, USA, 2018.
2. Ganesan V, "Internal Combustion Engine", 4th Edition, McGraw Hill Publishers, 2017
3. Rudramoorthy R, "Thermal Engineering", 3rd Edition, Tata McGraw Hill Publishers, 2017

212MEC2318 HEAT AND MASS TRANSFER	L	T	P	X	C
	2	1	2	0	4
Prerequisite: Thermal Engineering (MEC21RXXX)	Course Category: Program core course Course type: Integrated Course- Theory				

Course Objectives:

To understand various modes of heat transfer studies with analytical, experimental and numerical approaches

Course Outcomes:

CO1	Apply and interpret the radical concepts on steady and transient state heat conduction problems
CO2	Solve free and forced convection problems using correlations and perform experimentation
CO3	Investigate the phenomenon of boiling, condensation and heat exchanger equipment design
CO4	Conduct and investigate the basic occurence of radiational concepts
CO5	Interpret the fundamental concepts on mass transfer and cooling of electronic equipment

Mapping of Course Outcomes:

PO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
ASO	**1**	**2**	**2**	**3**	**6**	**5**	**5**	**5**	**7**	**4**	**6**	**6**	**1,2**	**3,4,7**	**2,6**
CO1	3	3	2	2	2				2	2		2	3	2	2
CO2	3	3	1	2	2				2	2		2	3		2
CO3	3	3	2	2	2				2	2		2	3	2	2
CO4	3	3	3	2	2				2	2		3	3	2	2
CO5	3	2	2	2	2				2	2		2	2	2	

Course Topics

UNIT I: CONDUCTION

Modes of heat transfer – Fundamental Laws - Applications - Thermal contact resistance; Overall heat transfer coefficient. One dimensional steady state conduction in simple geometries - General equation of heat conduction in Cartesian, cylindrical and spherical coordinates - Conduction in plane wall, cylindrical and spherical shells; Electrical analogy; Conduction in composite walls and shells; Critical thickness of insulation; Heat transfer through fins; Unsteady state heat transfer – Systems with negligible internal resistance -lumped heat capacity analysis; Infinite bodies; Semi-infinite bodies.

UNIT II: CONVECTION

Mechanism of convection - classification - Types of Flow - non-dimensional numbers in heat transfer; Boundary layer concepts for flow over a flat plate and flow through circular pipes; Forced convection - External flow over flat plate, cylinder, sphere and bank of tubes; Internal flow through circular pipes; Natural convection: Steady one-dimensional flow over vertical, horizontal plates, horizontal cylinders and spheres; combined free and forced convection.

UNIT III: CONVECTIVE PHASE CHANGE HEAT TRANSFER AND HEAT EXCHANGERS

Condensation and boiling – boiling modes, correlations, forced convection boiling, laminar film condensation on a vertical plate, turbulent film condensation; Heat exchangers – design procedure for heat exchanger - LMTD and NTU analysis, fouling factor, effectiveness.

UNIT IV: RADIATION

Thermal Radiation - Black body and real surface radiation; Radiation properties and governing laws; Radiation heat transfer - view factor and its relations - Radiation heat exchange between black and gray surfaces, Radiosity - Radiation shields and the radiation effects.

UNIT V: MASS TRANSFER AND COOLING OF ELECTRONIC EQUIPMENTS

Mass transfer – Fick's law of diffusion, diffusion mass transfer, forced convective mass transfer, heat and mass transfer analogies; Manufacturing of electronic equipment; Conduction in Cooling - Chip Carriers - PCB - TCM; Air cooling in forced and Natural convection.

Practical

Unit 1
Determination of thermal conductivity of insulating powder.
Determination of overall heat transfer coefficient using composite wall apparatus.
Determination of thermal conductivity using Lagged Pipe apparatus

Unit 2
Determination of heat transfer coefficient in natural convection mode.
Determination of heat transfer coefficient in forced convection mode.
Determination of heat transfer coefficient in natural convection mode in pin-fin apparatus.
Determination of heat transfer coefficient in forced convection mode in pin-fin apparatus.

Unit 3
Determination of effectiveness of Parallel flow heat exchanger.
Determination of effectiveness of counter flow heat exchanger

Unit 4
Determination of emissivity using emissivity apparatus.
Determination of Stefan Boltzmann constant using test rig.

Unit 5
Determination of drying efficiency in relevance to air flow using an air dryer.
Determination of diffusivity using diffusion measurement apparatus.

Text Book(s):

1. Yunus A. Cengel, Afshin J. Ghajar, Heat and Mass Transfer: Fundamentals and Applications, Tata Mc Graw Hill publications, Sixth Edition 2020.
2. Sachdeva, R. C., Fundamentals of Engineering Heat and Mass Transfer, New Age International Publishers, Fifth Edition 2017.

Reference(s):

1. Frank, P., Incropera and David, P. D., Fundamentals of Heat and Mass Transfer, John Wiley publication, Seventh Edition, 2017.
2. Rajput, R. K., A Text book of Heat and Mass Transfer, S. Chand Publication, New Delhi, 7th edition, 2019.
3. Holman, J.P., Heat and Mass Transfer, Tata McGraw-Hill,10th edition, 2011.
4. Kothandaraman, C.P., Fundamentals of Heat and Mass Transfer, New Age International, New Delhi,5th edition, 2016.

PROGRAM ELECTIVE COURSES

Common for

“Digital Manufacturing & Industry 4.0”

“Mechatronics & Automation”

And

Automotive System Engineering

213MEC1401 **BASICS OF ROBOTIC SIMULATION**		L	T	P	X	C
		2	0	4	0	4
Prerequisite: Nil	Course Category: Professional Elective Course type: Integrated Course-Practical					

Course Objectives:

To provide an overview of electronic devices and robotics simulations concepts

Course Outcomes:

CO1	Understand the principles of simulation and its environment.
CO2	Design a replication of actual manufacturing process
CO3	Understand the importance of robotics in production line
CO4	Understand the standard engineering manufacturing process in a simulation environment.
CO5	Learn the application of robotics in multiple domains

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	1	2	2	3	6	5	5	5	7	4	6	6	1,2	3,4,7	2,6
CO1	3	1										1	3		
CO2		3	2				1					2	2	2	2
CO3	1	2											3	3	3
CO4		3										3	2		
CO5		3					2					3	2		

Course Topics

UNIT I: INTRODUCTION TO SIMULATION ENVIRONMENT

Basic Environment - Study creation - Creating sequences of simulative operations - Collision detection - Section cutting - Video and picture output

UNIT II: KINEMATICS

Defining kinematic devices

Unit III: ROBOT AUTOMATION

Defining and simulating robotic spot welding - Pneumatic and servo gun definition and usage - pedestrial welding and Gun on robot path development

UNIT IV: SIMULATION

Defining and simulating robotic continuous applications - Arc welding and grinding path development

UNIT V: APPLICATION

Defining and simulating robotic material handling- Gripper definition and usage- Pick and place path development.

Additional Topics:

Multi-robot simulation (i.e. interference zones) - Swept volumes, 7th axis, etc

Text Book:

1. M.O. Tokhi , "Flexible Robot Manipulators: Modelling, simulation and control (Control, Robotics and Sensors)", Institution of Engineering and Technology; 2nd edition, 2017.

Reference:

2. Alcy Rodolfo Dos Santos Carrara, Mohamed Dokainish, "Dynamics, Simulation and Control of Flexible Robotic System", Novas Edicoes Academicas, 2018.
3. Mohammed Fazlur Rahman (Editor), Sanjeet K. Dwivedi, "Modeling, Simulation and Control of Electrical Drives", Institution of Engineering and Technology, 2019.

213MEC1402 **SYNCHRONOUS MODELLING WITH NX CAD**		L	T	P	X	C
		2	0	4	0	4
Prerequisite: Nil	Course Category: Professional Elective Course type: Integrated Course-Practical					

Course Objectives:

To enable the students about modelling and assembly of machine components

Course Outcomes:

CO1	Demonstrate various drawing conventions, abbreviations and their usage
CO2	Apply the knowledge of dimensioning, fits and tolerance in industrial sectors
CO3	Draw machine element using NX designer tools
CO4	Outline the drawing principles of synchronous modelling
CO5	Combine the various drawn parts of the component into assembled view

Mapping of Course Outcomes:

PO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
ASO	**1**	**2**	**2**	**3**	**6**	**5**	**5**	**5**	**7**	**4**	**6**	**6**	**1,2**	**3,4,7**	**2,6**
CO1	1	2	3						1	3			2		1
CO2	3	1	3		1				3	3		1	3	1	2
CO3	3	1	3		1				3	3			3		2
CO4	3	1	3		1				3	3			3	1	2
CO5	3	1	3		1				3	3			3	1	3

Course Topics

UNIT I: NX ADVANCED USER

Working with existing parts-Hole features -Expressions -Coordinate systems -Part Navigator -Associative -copies -Face and edge operations -Basic freeform -Creating and modifying assemblies

Assembly Constraints - Assembly Arrangements -Reference Sets -Interpart geometry and references -Component arrays -Reuse Library -Revise and replace components

UNIT II: SYNCHRONOUS MODELLING

Documenting design intent (Feature Groups, Product Interfaces) - Editing parametric models (Replace features, Suppression by Expression, model updates) - Associative curve operations (Project, Join, Intersect, Wrap/Unwrap, Text)

Emboss geometry (Emboss Body, Emboss, Offset Emboss) -Blending techniques (Advanced Edge Blend options, Face blends) - Interpart references (Interpart Expressions, Overriding Expressions) - Capturing part shape variations (Deformable Parts) - Design optimization (Optimization Study, Local and Global algorithms)

Intro to Synchronous modeling (Move, Pull, Replace, Delete Face) - Modifying detail features using Synchronous (Resize Blend, Chamfer, Replace Blend) - Reusing and relating faces using Synchronous (Pattern Face, Copy/Paste Face, Dimensions) - Optional: History-Free Synchronous (Optimize Face, Adaptive)

Text Book:

1. Jože Duhovnik , Ivan Demsar, Primož Drešar , "Space Modeling with SolidWorks and NX", Springer, 2015.

Reference:

2. Sachidanand Jha, "SIEMENS NX EXERCISES", 2019.
3. NX 10 Tutorial: Sketching, Feature Modeling, Assemblies, Drawings, Sheet Metal, and Simulation basics, 2015.

213MEC2403 **FACTORY CAD**	L	T	P	X	C
	1	0	6	0	4

Prerequisite: Nil	Course Category: Professional Elective Course type: Integrated Course-Practical

Course Objectives:

The aim of this course is to develop basic understanding of plant layout and material handling

Course Outcomes:

CO1	Outline the basics of factory CAD and their importance.
CO2	Develop the modelling of smart objects using the tools
CO3	Create the facility to importing the objects developed by the tools
CO4	Ability to analyze the various models created and prepare the documents
CO5	Outline various machines and material handling processes

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	1	2	2	3	6	5	5	5	7	4	6	6	1,2	3,4,7	2,6
CO1	2	3	2			2	2				1			2	
CO2	3	3	3		2	2	1						2	3	
CO3		3	2		3						1	1		2	
CO4	2	2	3	3	1						3				
CO5	1	3		1			2				1			2	

Course Topics

UNIT I: BASICS OF FACTORY CAD

Smart factory objects - Creating an new facility layout - Exporting a layout to a visualization program

UNIT II: CREATION OF SMART OBJECTS

Layer organization and standards - Creating generic tool objects

UNIT III: CREATION OF LIBRARIES AND IMPORTING OBJECTS
Using the Factory Explorer and Factory libraries - Importing tooling and product geometry

UNIT IV: ANALYSE AND DOCUMENTATION
Analyzing and documenting space use - Animating within Factory CAD - Building custom parametric objects

UNIT V: MACHINES AND MATERIAL HANDLING
Converting 2D outlines to 3D objects - Building systems from custom objects - Querying drawing objects.

Text Book:
1. Groover, Mikell, and E. W. J. R. Zimmers, "CAD/CAM: computer-aided design and manufacturing", Pearson Education, 1983.
2. Radhakrishnan, Pezhingattil, S. Subramanyan, and V. Raju. "CAD/CAM/CIM", New Age International, 2008.

Reference:
1. Stover, Richard N, "An Analysis of CAD/CAM Applications: with an introduction to CIM" Prentice Hall, 1984.
2. Issa, Raymond, Ian Flood, and W. O'Brien, "4D CAD and visualization in construction: Developments and applications", Taylor & Francis, 2003.
3. Canetta, Luca, Claudia Redaelli, and Myrna Flores, "Digital Factory for human-oriented production systems", Springer, 2014.
4. Bogdan, Stjepan, Frank L. Lewis, Zdenko Kovacic, and José Mireles, "Manufacturing systems control design: A matrix-based approach", Springer Science & Business Media, 2006.
5. Leondes, Cornelius T, "Computer Aided and Integrated Manufacturing systems", Vol. 5, World Scientific, 2003.

PROGRAM ELECTIVE COURSES (Digital Manufacturing & Industry 4.0)

213MEC2404 ADDITIVE MANUFACTURING		L	T	P	X	C
		1	0	6	0	4
Prerequisite: Nil	Course Category: Professional Elective Course type: Integrated Course-Practical					

Course Objectives:

To understand the 3D printing principles and methods

Course Outcomes:

CO1	Understand the principles of 3D Printing technique
CO2	Illustrate the methods of modelling and correction in 3D volumes
CO3	Apprehend the principles of finishing and materials

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	**1**	**2**	**2**	**3**	**6**	**5**	**5**	**5**	**7**	**4**	**6**	**6**	**1,2**	**3,4,7**	**2,6**
CO1	2		1		1						2		2	1	
CO2	2		1		2						2		2	1	
CO3	2		3		3						2		2	2	1

Course Topics

UNIT I: BASICS

Introduction to 3D printing techniques FDM, SLA, SLS, Generation of .stl format for 3D volume

UNIT II: MODELLING OF OBJECTS

Examination of Errors – holes, faces normal, self-intersections, noise shells, manifold errors, Repairing of Errors according to technique selection, Finishing and thread control

UNIT III: MATERIAL MOVEMENT AND UNITS

Materials and 3D printing- Introduction to white light scanning- Operation of Printer software controls and rectifications of model

Text Book:

1. Zhang, Jing, and Yeon-Gil Jung, “Additive manufacturing: materials, processes, quantifications and applications”, Butterworth-Heinemann, 2018.
2. M. Manjaiah K. Raghavendra N. Balashanmugam J. Paulo Davim, “ Additive Manufacturing”, Woodhead Publishing, 2021.
3. Chua, Chee Kai, and Kah Fai Leong, “3D Printing and additive manufacturing: Principles and applications of rapid prototyping”, World Scientific Publishing Company, 2014.

Reference:

1. Gebhardt, Andreas, and Jan-Steffen Hötter, “Additive manufacturing: 3D printing for prototyping and manufacturing”, Carl Hanser Verlag GmbH Co KG, 2016.
2. Leary, Martin, “Design for additive manufacturing”, Elsevier, 2019.
3. Zohdi, Tarek I, “Modeling and Simulation of Functionalized Materials for Additive Manufacturing and 3D Printing: Continuous and Discrete Media”,Springer, 2017.
4. Froes, Francis H., and Rodney Boyer, “Additive manufacturing for the aerospace industry”, Elsevier, 2019.
5. Haigh, Gerald. "The world of 3D printing." Seced, 2014.

List of Experiments

Modeling and printing of

1. Impossible box
2. Race Car
3. Differential gear
4. Jewelry die using resin printer
5. Mould for casting using resin printer

213MEC2405 INDUSTRIAL INTERNET OF THINGS		L	T	P	X	C
		2	0	4	0	4
Prerequisite: Nil	Course Category: Professional Elective Course type: Integrated Course-Practical					

Course Objectives:

To impart the principles of internet of things towards various industrial applications

Course Outcomes:

CO1	Understand the basics and structure of internet of things
CO2	Illustrate the characteristics of IoT sensors of first and advanced generations
CO3	Outline the various modules of IoT systems
CO4	Apply the industrial IoT principles for various applications
CO5	Able to apply the concepts of IoT to various projects

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	1	2	2	3	6	5	5	5	7	4	6	6	1,2	3,4,7	2,6
CO1	2	2		1	1							2	2	2	1
CO2	2	2		2	2							2	2	1	
CO3	1	2		1	2							2	1	2	1
CO4	2	1		2	2							1	1	2	1
CO5	2	1		2	1							2	1	2	2

Course Topics

UNIT I: INTRODUCTION

Internet of Things Promises–Definition– Scope–Sensors for IoT Applications–Structure of IoT–IoT Map Device.

UNIT II: IOT SENSORS

Industrial sensors – Description & Characteristics–First Generation – Description & Characteristics– Advanced Generation – Description & Characteristics–Integrated IoTSensors – Description & Characteristics–Polytronics Systems – Description & Characteristics–Sensors'

Swarm – Description & Characteristics–Printed Electronics –Description & Characteristics–IoT Generation Roadmap.

UNIT III: TECHNOLOGICAL ANALYSIS
Wireless Sensor Structure–Energy Storage Module–Power Management Module–RF Module–Sensing Module.

UNIT IV: IOT DEVELOPMENT EXAMPLES
ACOEM Eagle – En Ocean Push Button – NEST Sensor – Ninja Blocks -Focus on Wearable Electronics.

UNIT V: IOT PROJECTS
Creating the sensor project - Preparing Raspberry Pi/ ARM Cortex - Clayster libraries - HardwareInteracting with the hardware - Interfacing the hardware- Internal representation of sensor values - Persisting data - External representation of sensor values – Exporting Sensor data - Creating the actuator project- Hardware - Interfacing the hardware -Creating a controller - Representing sensor values - Parsing sensor data – Calculating control states - Creating a camera - Hardware -Accessing the serial port on RaspberryPi/ ARM Cortex - Interfacing the hardware - Creating persistent default settings – Adding configurable properties - Persisting the settings - Working with the current settings -Initializing the camera.

Text Book:
1. Giacomo Veneri , Antonio Capasso, "Hands-On Industrial Internet of Things: Create a powerful Industrial IoT infrastructure using Industry 4.0 ", Ingram short title, 2018.

Reference:
1. Sabina Jeschke, Christian Brecher, Houbing Song , Danda B. Rawat, "Industrial Internet of Things: Cybermanufacturing Systems", Springer, 2018.
2. Alasdair Gilchrist , "Industry 4.0: The Industrial Internet of Things", Apress, 2019.

Practical:
1. Automatic Human Trolly
2. Solar and Smart Energy System
3. Machine Health Monitoring System

Other experiments can be framed based on the demand at the time of studying

213MEC2301 BIG DATA ANALYTICS FOR MANUFACTURING	L	T	P	X	C
	3	0	2	0	4

Prerequisite: Nil	Course Category: Professional Elective Course type: Integrated Course with Theory

Course Objectives:

To Understand the competitive advantage of big data analytics and its frameworks.
To Learn Data analysis methods and stream computing.
To gain knowledge on Hadoop related tools such as HBase, Cassandra, Pig, and Hive for big data analytics.

Course Outcomes:

CO1	Enumerate the features, evolution and modern tools of Data Analytics.
CO2	Analyze the various methods of HADOOP framework.
CO3	Illustrate the statistical methods of Data analysis and Data analysis using R.
CO4	Analyze data by utilizing various data mining approaches
CO5	Understand the various NoSql alternative database models

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	1	2	2	3	6	5	5	5	7	4	6	6	1,2	3,4,7	2,6
CO1	2				1							1			
CO2	1				3							2			2
CO3	1				2							2			2
CO4	1				3							2			2
CO5	2				3							1			2

Course Topics

UNIT I: INTRODUCTION TO BIG DATA

Big Data – Definition, Characteristic Features – Big Data Applications - Big Data vs Traditional Data - Risks of Big Data - Structure of Big Data - Challenges of Conventional Systems - Web Data – Evolution of Analytic Scalability - Evolution of Analytic Processes, Tools and methods - Analysis vs Reporting - Modern Data Analytic Tools.

UNIT II: SYSTEM ORGANIZATION

Distributed File Systems - Large-Scale File System Organization – HDFS concepts - MapReduce Execution, Algorithms using MapReduce, Matrix-Vector Multiplication – Hadoop YARN.

UNIT III: DATA ANALYSIS

Statistical Methods: Regression modelling, Multivariate Analysis - Classification: SVM & Kernel Methods - Rule Mining - Cluster Analysis, Types of Data in Cluster Analysis, Partitioning Methods, Hierarchical Methods, Density Based Methods, Grid Based Methods, Model Based Clustering Methods, Clustering High Dimensional Data - Predictive Analytics – Data analysis using R.

UNIT IV: MINING DATA STREAMS

Streams: Concepts – Stream Data Model and Architecture - Sampling data in a stream - Mining Data Streams and Mining Time-series data - Real Time Analytics Platform (RTAP) Applications - Case Studies - Real Time Sentiment Analysis, Stock Market Predictions.

UNIT V: BIG DATA FRAMEWORKS

Introduction to NoSQL – Aggregate Data Models – H base: Data Model and Implementations – H base Clients – Examples – Cassandra: Data Model – Examples – Cassandra Clients – Hadoop Integration. Pig – Grunt – Pig Data Model – Pig Latin – developing and testing Pig Latin scripts. Hive – Data Types and File Formats – HiveQL Data Definition – HiveQL Data Manipulation – HiveQL Queries.

<u>Practical:</u>

1. Downloading and installing Hadoop; Understanding different Hadoop modes. Startup scripts, Configuration files.
2. Hadoop Implementation of file management tasks, such as Adding files and directories, Retrieving files and Deleting files
3. Implement of Matrix Multiplication with Hadoop Map Reduce
4. Run a basic Word Count Map Reduce program to understand Map Reduce Paradigm.
5. Implementation of K-means clustering using Map Reduce
6. Installation of Hive along with practice examples.
7. Installation of HBase, Installing thrift along with Practice examples
8. Patrice importing and exporting data from various databases .

Text Book:

1. Bill Franks, “Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics”, Wiley and SAS Business Series, 2012.
2. David Loshin, "Big Data Analytics: From Strategic Planning to Enterprise Integration with Tools, Techniques, NoSQL, and Graph", 2013.

Reference:

1. Learning R – A Step-by-step Function Guide to Data Analysis, Richard Cotton, O‟Reilly Media, 2013.
2. Michael Berthold, David J. Hand, “Intelligent Data Analysis”, Springer, Second Edition, 2007.
3. Michael Minelli, Michelle Chambers, and Ambiga Dhiraj, "Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses", Wiley, 2013.
4. P. J. Sadalage and M. Fowler, "NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence", Addison-Wesley Professional, 2012

213MEC2302 **SMART MANUFACTURING AND INDUSTRY 4.0**	L	T	P	X	C
	3	0	2	0	4
Prerequisite: Nil	Course Category: Professional Elective Course type: Integrated Course with Theory				

Course Objectives:

To provide students with the concepts of planning manufacturing systems, computer integrated manufacturing and enterprise integration, group Technology and knowledge based systems.

Course Outcomes:

CO1	Assess the performance of manufacturing systems and CIM systems.
CO2	Develop a systematic approach for design and implementation of manufacturing systems.
CO3	Interpret new procedures to improve the productivity of existing manufacturing systems.
CO4	Enumerate the model and algorithm of Group Technology.
CO5	Analyze the impact of knowledge based group technology systems in automated manufacturing system.

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	1	2	2	3	6	5	5	5	7	4	6	6	1,2	3,4,7	2,6
CO1	2	3		2	2		1					2	3	1	2
CO2	1	3		3	2							1	2	2	2
CO3	1	1		2			1					3	3	1	
CO4	1	1		3	2		1					3	3	2	
CO5	1	2		2								2	3	2	

Course Topics

UNIT I: COMPUTER INTEGRATED MANUFACTURING

Computer integrated manufacturing systems – structure and functional areas of CIM system - AD, CAPP, CAM, CAQC, ASRS and advantages of CIM Manufacturing communication systems – MAP/TOP OSI model, data redundancy, top-down and bottom-up approach, volume of information. Intelligent manufacturing – system components, system architecture and data flow, system operation

UNIT II: ARTIFICIAL INTELLIGENCE

Components of knowledge-based systems – basic components of knowledge-based systems, knowledge representation, comparison of knowledge representation schemes, interference engine, knowledge acquisition Machine learning – concept of artificial intelligence, conceptual learning, artificial neural networks -biological neuron, artificial neuron, types of neural networks, applications in manufacturing

UNIT III: PROCESS PLANNING

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, modelling the manufacturing equipment selection problem, problem solving approach in KBSES, structure of the KBSES

UNIT IV: GROUP TECHNOLOGY

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.

UNIT V: KNOWLEDGE BASE SYSTEM

Knowledge based group technology - group technology in automated manufacturing system, structure of knowledge-based system for group technology (KBSGT) – data base, knowledge base, clustering algorithm

List of Practical Component

1. Study of Smart factory architecture
2. Smart factory modelling in terms of resources, organization, information, and function
3. Resource scheduling within a smart factory
4. Supply chain scheduling
5. Energy-efficient machining decision-making for Industry 4.0
6. Ontology-based approach to process planning
7. Manufacturing resource representation for a smart factory

8. Implementation of Smart product configuration system.

Text Book:

1. Mikell P. Groover, “Automation, Production Systems and Computer Integrated Manufacturing”, 8th edition, PHI, 2008.
2. Alasdair Gilchrist, “Industry 4.0: The Industrial Internet of Things”, A press, 2016.

Reference:

1. Yagna Narayana, “Artificial Neural Networks”, PHI, 2009.
2. Andre Kusaic, “ Intelligent Manufacturing Systems”, PHI,1989
3.Hamid R. Parsaei and Mohammad Jamshidi, “Design and Implementation of Intelligent Manufacturing Systems”, PHI, 2009

<table>
<tr><td rowspan="2">213MEC2303

PRODUCTION DRAWING AND MANUFACTURING ANALYSIS</td><td>L</td><td>T</td><td>P</td><td>X</td><td>C</td></tr>
<tr><td>3</td><td>0</td><td>2</td><td>0</td><td>4</td></tr>
<tr><td>Prerequisite: Nil</td><td colspan="5">Course Category: Professional Elective
Course type: Integrated Course with Theory</td></tr>
</table>

Course Objectives:

To understand the basic concept of production drawing and analysis of Manufacturing systems in industries.

Course Outcomes:

CO1	Analyze the principle and working model of manufacturing systems.
CO2	Interpretation of Line balancing algorithm and production flow analysis.
CO3	Analysis of FMS and Group Technology systems in manufacturing.
CO4	Enumerate the principle of material handling system and AGV in manufacturing industries.
CO5	Understand the basic concept of Storage and Retrieval systems.

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	1	2	2	3	6	5	5	5	7	4	6	6	1,2	3,4,7	2,6
CO1	3	1		2							1	3	3	2	
CO2	2	1		2								2	3		
CO3	3	2		3							2	2	3	2	
CO4	2	1		2							1	3	3		
CO5	3	1		2							1	2	3		

Course Topics

UNIT I: MANUFACTURING SYSTEMS MODEL

Introduction to manufacturing systems models, types and principles of manufacturing systems, manufacturing models, types and uses physical models, mathematical models, model uses, model building, numerical problems/simulation exercises.

UNIT II: ASSEMBLY LINES

Introduction to assembly lines, line balancing algorithms, COMSOL random sequence generation, ranked positional weight, heuristics, optimal solutions, practical issues, mixed models, sequencing unpaced lines, shop scheduling with many products, order release, flow shop sequencing, single and two machine flow shops, job shop scheduling, dispatching rules and schedule generation, numerical problems/simulation exercises

UNIT III: FLEXIBLE MANUFACTURING SYSTEM

Introduction to FMS, components of FMS machines, movement system, work stations, system controller, planning and control hierarchy, system design, system set up, scheduling and control, flexible assembly system Group technology principles, coding schemes, assign machines to groups, production flow analysis, binary ordering algorithm, assigning parts to machines.

UNIT IV: MATERIAL HANDLING SYSTEMS

Introduction, types and principles of material handling systems, equipment selection, conveyor analysis, closed loop conveyor, AGV systems, design and operation of AGVs vehicle, requirements, analysis, pallet sizing and loading, use of petri nets

UNIT V: STORAGE SYSTEMS

Introduction to warehousing and storage and retrieval system, warehouse components, warehouse design, stacking pattern, location in warehouses, dedicated storage, open storage, class base storage, storing complementary items, order picking, forming pick list, pick sequencing.

List of Practical Component

1. Product knowledge management tools, methods, and techniques for one-of-a-kind production
2. Enabling technology for rapid development of high value-added customised product
3. Manufacturing resource representation for a smart factory.
4. Simulation exercise on Job shop scheduling.
5. Develop an Automatic guided Vehicle for a pick and place application.
6. Enable quality management; create tests, item sampling, definitions and process of the quality management process.
7. Create a manual quality order with a specification.
8. Work with non-conformance issues like faulty items by defining several required specifications.

Text Book:

1. Groover M.P. Automation Production Systems and Computer Integrated Manufacturing Prentice-Hall of India Pvt. Ltd, 2016.
2. Kalpakjian Manufacturing Engineering and Technology Addison-Wesley Publishing Co, 2020.

Reference:

1. H. K. Shivanand, Flexible Manufacturing System, New Age International Pvt Ltd, Edition 1, 2006.
2. Ronald G. Askin and Charles R. Standridge Modeling and analysis of manufacturing systems John Wiley & Sons Inc, 1993.

213MEC2304 APPLICATION OF AR AND VR IN MANUFACTURING	L	T	P	X	C
	3	0	2	0	4
Prerequisite: Nil	Course Category: Professional Elective Course type: Integrated Course with Theory				

Course Objectives:

This course presents an introduction to virtual and augmented reality technologies, with an emphasis on designing and developing interactive virtual and augmented reality experiences.

Course Outcomes:

CO1	Understand the basics of AR and VR in Manufacturing.
CO2	Enumerate the technology of VR and 3D data structures.
CO3	Interpret the Framework of AR in the industrial environment and AIBAS system.
CO4	Analyze the impact of AR in new user interfaces in the manufacturing industry.
CO5	Analyze the manufacturing and service applications of Augmented Reality.

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	1	2	2	3	6	5	5	5	7	4	6	6	1,2	3,4,7	2,6
CO1	3	2		2	3						1	3	3	2	3
CO2	3	2		3	2						1	2	3	2	2
CO3	3	3		3	2						2	2	3	3	1
CO4	3	2		2	1						1	3	3	2	2
CO5	3	2		2	1						1	2	3	3	2

Course Topics

UNIT-I: SOLID MODELING OF VR

Introduction of VR and AR applications in Manufacturing- Background of AR and VR Technologies- AR Technologies: Registry, Latency, Calibration, Human Factors- Research Issues- VR in manufacturing- AR in manufacturing- Solid Modelling in a Virtual Reality Environment- Structure of the Constraint-based Model- Polygon Model Representation- Constraint-based Manipulations-

UNIT-II: VIRTUAL ENVIRONMENTS

VR Technology – Applications- Collaborative Virtual Reality- Data Transfer Between Virtual Environments- Data Controller in Collaborative Virtual Manufacturing- Object Data Structures in Virtual Reality Manufacturing - Architecture of Data-Traffic Controller- Data-Control Engine- Elements of Data Control Engine- A Supervisory Data-Traffic Controller-Decision Support System for Integrating Real-time Manufacturing- 3D Data Structures- Basic Manufacturing Operations

UNIT-III: AR ENVIRONMENTS

AR Technology - Devices and Technology- AR Framework in Industrial Environments- Adaptive Intent based Augmentation System (AIBAS)- Communicative Intent in AR- Strategies for Visual Context- Inset Windows to Reduce Ambiguity- AIBAS System Implementation: Augment a Hidden Object, Augment a Unique Visible Object, Augment an Ambiguous Visible Object, Augment a Scene with Virtual Objects

UNIT-IV: AR NETWORKING

Augmented Reality as a New User Interface: For Layout Planning of Manufacturing Systems- AR-based Manufacturing Planning System- Construction functions- Simulation of Planning Stages- Realization of the Prototype- Teleportal Augmented Reality System: Integrating Virtual Objects, Remote Collaborators, and Physical Reality for Distributed Networked Manufacturing

UNIT-V: AR SERVICE APPLICATIONS

AR Technology - Manufacturing and Service Applications- Developing and Applying AR Technology in Design, Production, Service and Training- Mobile Service Applications for Machine Tools- Validation of the Dynamics of a Parts Feeding System - Vision-based Augmented Reality for Guiding Assembly- Performance Evaluation of Augmented Reality for Directed Assembly- The Intelligent Welding Gun: Augmented Reality for Experimental Vehicle Construction- Helmet for the Manual Welding Process

Practical:

1. Installation of Unity and Visual Studio, setting up Unity for VR development, understanding documentation of the same.
2. Develop an innovative Augmented Reality Android App
3. Perform Augmented Reality and Real 3D object Tracking
4. Develop an Augmented Reality Video Playback.
5. Augmented Reality for animation
6. Augmented Reality Internet of Things
7. Develop a scene in Unity that includes: Model 3D objects and apply transformations on the 3 game objects.
8. Simulation of circulation of blood in heart.

Text Book:

1. S. K. Ong, A. Y. C. Nee (auth.), S. K. Ong PhD, A. Y. C. Nee DEng, PhD (eds.) - Virtual and Augmented Reality Applications in Manufacturing-Springer-Verlag London (2004)

Reference:

1. Grigore C. Burdea, Philippe Coiffet , Virtual Reality Technology, Wiley 2016
2. Dieter Schmalstieg and Tobias Höllerer, Augmented Reality: Principles & Practice, Pearson Education India, 2016
3. Kent Norman (Ed), Wiley Handbook of Human Computer Interaction, Wiley 2017

213MEC2305 CYBER PHYSICAL SYSTEM IN MANUFACTURING	L	T	P	X	C
	3	0	2	0	4
Prerequisite: Nil	Course Category: Professional Elective Course type: Integrated Course with Theory				

Course Objectives:

This course deals with the advancements of cloud technology and functions of Cyber physical systems in the manufacturing domain.

Course Outcomes:

CO1	Enumerate the latest advancements of cloud technologies.
CO2	Interpret the concept of Distributed Process Planning (DPP) and its architecture.
CO3	Analyze the functions of Adaptive Machining Using Function Blocks.
CO4	Implementation of Cyber Physical System (CPS) in robotic assembly.
CO5	Enumerate the design and life cycle analysis of Cyber Physical System.

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	1	2	2	3	6	5	5	5	7	4	6	6	1,2	3,4,7	2,6
CO1	3	2		1	1							2	2	2	1
CO2	3	1		2	1							3	1	1	
CO3	2	2		1	2							2	2	1	1
CO4	3	2		1	1							2	2	2	
CO5	3	1		2	1							2	2	2	2

Course Topics

UNIT I: CLOUD TECHNOLOGY

Latest Advancement in Cloud Technologies- Introduction to Cloud Computing- Historical Evolution and Background- Latest Advancement in Cloud Technologies- Introduction to Cloud Computing- Historical Evolution and Background- Latest Advancement in CPS and IoT Applications- Introduction- Key Enabling- Technologies in CPS and IoT- Wireless Sensor Network- Could Technologies- Big Data- Industry 4.0- RFID Technology- Applications of CPS and IoT- Challenges in Cybersecurity

UNIT II: PROCESS PLANNING

Cloud-Based Monitoring, Planning and Control in CPS- Machine Availability Monitoring and Process Planning- Concept of Distributed Process Planning- Architecture Design of a Web-Based DPP- Functional Analysis of Web-DPP- Web-DPP Prototype Implementing- Cloud-Enabled Distributed Process Planning- Multi-tasking Machines and Mill-Turn Parts

UNIT III: ADAPTIVE MACHINING

Adaptive Machining Using Function Blocks- Introduction- Function Block Concept- Function Block Types- Execution of Function Block- Internal Behaviour of Function Block- Enriched Machining Features- Adaptive Machining Feature Sequencing- Adaptive Setup Merging and Dispatching- Condition Monitoring for Predictive Maintenance- Fundamentals of Prognosis- Prognostic Methods- Physics-Based Models- AI-Based Data-Driven Models- Statistical Data-Driven Models- Model-Based Approach- Prognosis Applications

UNIT IV: ASSEMBLY SYSTEMS

Sustainable Robotic Assembly in CPS Settings- Methodology and Implementation- Case Studies: Energy Map of Robot Workspace, Energy Measurement in Predefined Paths- Safety in Human-Robot Collaborative Assembly- Depth Sensor-Driven Active Collision Avoidance- A Remote Assembly Application- Cloud Robotics Towards a CPS Assembly System- Gesture Recognition-Human Motion Prediction

UNIT V: SCHEDULING

CPS Systems Design and Lifecycle Analysis- Architecture Design of Cloud CPS in Manufacturing- Cloud Manufacturing Framework- Manufacturing Capability and Manufacturing Resource- Interoperability and Other Issues- Product Tracking and WEEE Management- Big Data Analytics for Scheduling and Machining- Big Data Analytics for Shop-Floor Scheduling- Big Data Analytics based Optimisation for Machining

Practical:

1. Develop a model using a Cyber Physical 3D printing system.
2. Experiment on Real-time manufacturing data acquisition.
3. Interpret Data communication, integration and management using CPS System.
4. Machine tool information modelling using Cyber Physical System.
5. Augmented Reality (AR)-based visualization of machine tool status and machining processes.
6. Semantic Machine-to-Machine (M2M) communication between field-level manufacturing. devices (e.g. machine tools, AGVs, robots)

Text Book:

1. Lihui Wang, Xi Vincent Wang - Cloud-Based Cyber-Physical Systems in Manufacturing-Springer International Publishing (2018)

Reference:

1. Rajeev Alur, Principles of Cyber-Physical Systems (The MIT Press), 2015.
2. Taha, Walid M., Cyber-Physical Systems: A Model-Based Approach, Springer Nature, 2020

PROGRAM ELECTIVE COURSE (Mechatronics & Automation)

213MEC2406 **PLANT SIMULATION**	L	T	P	X	C
	3	0	2	0	4

Prerequisite: Nil	Course Category: Professional Elective Course type: Integrated Course-Theory

Course Objectives:

To understand the application of computers in various aspects of Manufacturing viz., Design, Proper planning, Manufacturing cost, Layout & Material Handling system.

Course Outcomes:

CO1	Outline the plant simulation strategies and their importance
CO2	Creating the model of the objects by using the drafting tools
CO3	Illustrate the material movement process and the units utilized.
CO4	Illustrate the use of analysis tools use for plant simulation process
CO5	Categorize the data handling and processing methods

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	1	2	2	3	6	5	5	5	7	4	6	6	1,2	3,4,7	2,6
CO1	2		1		1						2		2	1	
CO2	2		1		2						2		2	1	
CO3	2		3		3						2		2	2	1
CO4	2		1		3						2		2	3	3
CO5	2		2		3						3	2	2	2	2

Course Topics

UNIT I: BASICS OF PLANT SIMULATION

Basic Plant Simulation interface- Object-oriented modeling strategies - Basics of material flow objects - Hierarchy, icons, and inheritance

UNIT II: MODELLING OF OBJECTS

Modeling buffers, assembly lines and roads, Kanban, and failures, Resource objects (i.e. workers and shift calendars), Resource objects (i.e. workers, shift calendars, foot paths, etc.)

UNIT III: MATERIAL MOVEMENT AND UNITS

Basic conveying systems (length-oriented objects), other objects (i.e. Information objects, User Interface objects, mobile units).

UNIT IV: ANALYSIS TOOLS

Sankey, bottleneck analyzer, and experiment manager basics, Customizing object logic (Method creation), Methods for data collection and evaluation

UNIT: DATA HANDLING

Methods for interfaces (Excel, DDE, basics of other interfaces), Data acquisition from external files and systems

Text Book:

1. Bangsow, Steffen, "Manufacturing simulation with plant simulation and simtalk: usage and programming with examples and solutions", Springer Science & Business Media, 2010.
2. Bangsow, Steffen. Tecnomatix plant simulation. Springer International Publishing, 2020.
3. Babu, B. V., "Process plant simulation", Oxford University Press, 2004.

Reference:

1. Prusinkiewicz, Przemyslaw, and Aristid Lindenmayer.,"The algorithmic beauty of plants", Springer Science & Business Media, 2012.
2. Zhou, Zude, Shane Shengquan Xie, and Dejun Chen, "Fundamentals of digital manufacturing science", Springer Science & Business Media, 2011.
3. Leonard, James V, "Simulation Systems", CRC Press, 2000.
4. Law, Averill M., and W. David Kelton, "Simulation Modeling and Analysis" The McGraw-Hill Companies, 2007.
5. Di Paolo Emilio, Maurizio, "Data Acquisition Systems From Fundamentals to Applied Design", Springer, 2013

213MEC1307 **ROBOTICS : FUNDAMENTAL CONCEPTS AND ANALYSIS**	L	T	P	X	C
	3	0	2	0	4
Prerequisite: Nil	Course Category: Professional Elective Course type: Integrated Course-Theory				

Course Objectives:

To impart the knowledge about the basics of robotics and their kinetics

Course Outcomes:

CO1	Understand the basics of robotics and their geometry
CO2	Enumerate the concepts of homogeneous transformation
CO3	Ability to apply the forward kinematics principles
CO4	Understand the inverse kinematics processes
CO5	Interpret the robotics motion in angular aspects

Mapping of Course Outcomes:

PO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
ASO	**1**	**2**	**2**	**3**	**6**	**5**	**5**	**5**	**7**	**4**	**6**	**6**	**1,2**	**3,4,7**	**2,6**
CO1	2	3		1	1							2	2	2	1
CO2	3	1		3	1							3	1	1	
CO3	2	2		1	2							2	2	1	1
CO4	3	2		1	1							2	2	2	
CO5	3	1		2	1							2	2	2	2

Course Topics

UNIT I: INTRODUCTION

Classification of Robots based on Geometry, Workspace, Actuation, Control and Application - Advantages and Disadvantages of Robots - Robot Components: Link, Joint, Manipulator, Wrist, End-effector : Gripper –Types, Actuator and Sensor - Configuration space – Joint Space – Workspace, Robot Specifications: Number of Axes:Internal and External (7-axis robot) - Capacity and Speed, Reach and Stroke, Tool Orientation, Repeatability, Precision and Accuracy, Operating Environment

UNIT II: HOMOGENEOUS TRANSFORMATIONS

Degrees of Freedom – Matrix Representation: Representation of a point and vector in space, Global and Local Coordinate axes - Homogeneous Transformation Matrices – Transformations: Representation of pure translation, Representation of pure Rotation - Representation of Combined Transformations - Inverse of Transformation Matrices - Euler Angles – Roll, Pitch, Yaw angles - Quaternions–Spinors and Rotations

UNIT III: FORWARD KINEMATICS

Denavit-Hartenberg Notation - Transformation between two Adjacent Coordinate Frames Forward Kinematics of Two, Three, Four, Five and Six axis Robots

UNIT IV: INVERSE KINEMATICS

Decoupling Technique - Inverse Transformation Technique - Inverse position: GeometricApproach – Inverse Orientation - Inverse Kinematics of Two, Three, Four, Five and Sixaxis Robots.

UNIT V: VELOCITY KINEMATICS

Angular Velocity – Linear Velocity - Jacobian representation of Linear and Angular Velocity Calculation of Jacobian for Two, Three and Four axis Robots - Inverse Jacobian - Singularities: Wrist and Arm Singularities - Manipulability - Induced joint torques and forces.

List of Practical Component

1. Programming on VAL Language
2. Programming on VAL-II Language
3. Programming on RAPID Language
4. Programming on AML Language
5. Programming the robot for pick and place operation using any robot
6. Robot Programming for Colour identification/shape identification/path tracking
7. Industrial visit and its report on industrial applications of robots

Text Book:

1. Mark W. Spong, Seth Hutchinson, M. Vidyasagar, "Robot Modeling and Control", Wiley, 2015.
2. Niku S B, "Introduction to Robotics, Analysis, Control, Applications", John-Wiley & Sons Inc, 2011.

Reference:

1. Robert J. Schilling, "Fundamentals of Robotics, Analysis and Control", PHI Learning, 2009.
2. Reza N Jazar, "Theory of Applied Robotics", Springer, 2010.
3. Saha S K, "Introduction to Robotics", Tata McGraw Hill Education Pvt. Ltd, 2010.
4. Tadej Bajd, Matjaž Mihelj, Marko Munih, "Introduction to Robotics", Springer, 2013.

213MEC2308 AUTOMATION SYSTEM DESIGN	L	T	P	X	C
	3	0	2	0	4
Prerequisite: Nil	Course Category: Professional Elective Course type: Integrated Course-Theory				

Course Objectives:

To provide the concepts of process automation and system integration principles

Course Outcomes:

CO1	Describe the model of automation system in various industries
CO2	Able to select the motion components for the given applications
CO3	Understand the terminologies and the process of automated assembly
CO4	Design of parts for high speed assembly applications
CO5	Enumerate the economics of automation system design

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	1	2	2	3	6	5	5	5	7	4	6	6	1,2	3,4,7	2,6
CO1	2	2		1	1							2	2	2	1
CO2	1	1		2	1							2	1	1	
CO3	1	2		1	2							2	1	1	1
CO4	3	1		2	1							1	2	2	
CO5	3	1		2	1							2	1	2	2

Course Topics

UNIT I: INTRODUCTION TO PROCESS AUTOMATION

Process Automation – paper industry, packaging industry, food processing industry, Integrated design issues in automation systems, the Mechatronics design process- benefits, modeling of electromechanical systems, bond graph technique, Automation migration strategy - building blocks of automation system

UNIT II: SELECTION OF MOTION COMPONENTS

Selection of motor for automation system, Calculation of inertia force for motor, LM Guide ways, Ball screws, Selection, from the manufacturer‟s catalogue based on the applications.

UNIT III: TRANSFER LINES AND AUTOMATED ASSEMBLY

General terminology-takt time, setup time and cycle time, Automated flow lines with storage buffers. Automated assembly-design for automated assembly, types of automated assembly systems, part feeding devices, analysis of multi-station assembly machines - modular fixturing - Flow line balancing

UNIT IV: DESIGN FOR HIGH SPEED AUTOMATIC ASSEMBLY

Introduction, Design of parts for high speed feeding and orienting, high speed automatic insertion, Analysis of an assembly, General rules for product design for automation – Application of high speed automatic assembly.

UNIT V: SYSTEM INTEGRATION

Issues and systematic approaches, design and simulation using CIROS software,economics of automation systems design and implementation

Text Book:

1. Mikell P Groove, "Automation Production Systems and Computer Integrated Manufacturing", Pearson education, New Delhi, 2016.
2. Geoffery Boothroyd, "Assembly Automation and Product Design", CRC Press, USA, 2016

Reference:

1. DevadasShetty , "Mechatronics System Design", PWS Publishing Company, USA, 2010.
2. Wilfried Voss, "A Comprehensible Guide to Servo Motor Sizing", Copperhill Technologies Corporation, Massachusetts, 2007.

213MEC2309 **AUTOMATIC CONTROL SYSTEM**		L	T	P	X	C
		3	0	2	0	4
Prerequisite: Nil	Course Category: Professional Elective Course type: Integrated Course-Theory					

Course Objectives:

To facilitate the students to learn and adopt the concepts of automatic control system

Course Outcomes:

CO1	Outline the components of automatic control system
CO2	Illustrate the procedure of time domain analysis
CO3	Able to estimate the second order system and also correlate time and frequency domain
CO4	Enumerate the concepts of state variables of and state models
CO5	Understand the concepts of stability and root locus

Mapping of Course Outcomes:

PO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
ASO	**1**	**2**	**2**	**3**	**6**	**5**	**5**	**5**	**7**	**4**	**6**	**6**	**1,2**	**3,4,7**	**2,6**
CO1	3	2		2	1							2	2	2	1
CO2	2	2		3	2							2	2	1	
CO3	1	2		1	2							2	1	2	1
CO4	3	1		2	1							1	2	2	2
CO5	3	1		2	1							2	1	2	2

Course Topics

UNIT I: INTRODUCTION

Components of Automatic control systems- Open loop and closed loop systems - Examples - Transfer function - Modeling of physical systems - Mechanical Systems - Translational and Rotational systems - Hydraulic systems and Electrical Systems - Transfer function of DC servomotor - AC servomotor - Block diagram - reduction techniques - Signal flow graph - Mason's gain formula.

UNIT II: TIME DOMAIN ANALYSIS

Continuous time signals - Standard Test signals - Classification of continuous time systems Linear- Nonlinear - Time variant - Time invariant - Static - Dynamic - Time response of second order system - Time domain specifications - Types of systems - Steady state error constants - Generalized error series - Introduction to P, PI and PID modes of feedback control. - Introduction to lead, lag and lead-lag compensators

UNIT III: FREQUENCY DOMAIN ANALYSIS
Frequency domain specifications - Estimation for second order systems- Correlation between time and frequency domain specifications for second order systems - . Bode plot – Determination of Transfer Function from Bode plot - All pass minimum phase and non-minimum phase systems - Polar plot - Determination of gain and phase Margins from the plots.

UNIT IV: STATE SPACE ANALYSIS
Limitations of conventional control theory - Concepts of state, state variables and state model - state model for linear time invariant systems - Introduction to state space representation using physical - Phase and canonical variables - State equations - Transfer function from the State model - Solutions of the state equations -State Transition Matrix - Concepts of controllability and observability

UNIT V: SYSTEM STABILITY
Concept of stability - stability & location of the poles in S-plane - Characteristic equation - Routh-Hurwitz stability criterion - Root Locus concepts- Construction of root locus – Root contours - Absolute and Relative stability - Nyquist stability - Nyquist stability criterion - Assessment of relative stability - Gain and Phase Margin.

Text Book:
1. Smarajit Ghosh, "Control Systems Theory and Applications", 2nd Edition, Pearson Education, New Delhi, 2012.
2. Ogata K, "Modern Control Engineering", 5th Edition, Pearson Education, New Delhi, 2009.

Reference:
1. Nagrath I J, Gopal M, "Control Systems Engineering", 5th Edition, Prentice Hall of India, New Delhi, 2008.
2. Richard C Dorf , Robert H Bishop , "Modern Control Systems", 12th Edition, Addison-Wesley, New Delhi, 2010.
3. Norman S Nise, "Control System Engineering", 6th Edition, John Wiley & Sons, Singapore, 2012.
4. S Palani, "Control Systems Engineering", 2nd Edition, McGraw Hill Education Pvt. Ltd, New Delhi, 2010.

213MEC2310 DYNAMICS AND CONTROL OF MANIPULATORS	L	T	P	X	C
	3	0	2	0	4
Prerequisite: Nil	Course Category: Professional Elective Course type: Integrated Course-Theory				

Course Objectives:

To make the students understand the function of dynamics and control of manipulators.

Course Outcomes:

CO1	Enumerate the acceleration and motion dynamics in various aspects
CO2	Outline the various equations used in robot dynamics
CO3	Understand the principles of various types of path planning
CO4	Develop the time optimal control for robots
CO5	Outline the control techniques used in robot design

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	1	2	2	3	6	5	5	5	7	4	6	6	1,2	3,4,7	2,6
CO1	2	2		2	1							2	2	2	1
CO2	2	2		1	2							3	2	1	
CO3	1	2		1	2							2	3	1	
CO4	2	2		2	1							1	2		2
CO5	2	1		2	1							2	1	2	2

Course Topics

UNIT I: ACCELERATION AND MOTION DYNAMICS

Angular Acceleration Vector and Matrix - Rigid Body Acceleration – Forward Acceleration Kinematics – Inverse Acceleration Kinematics - Force and Moment – Rigid Body Translational and Rotational Kinetics - Mass Moment of Inertia Matrix - Lagrange‟s form of Newton Equations - Lagrangian Mechanics

UNIT II: ROBOT DYNAMICS

Rigid-link Newton Euler Dynamics - Robot Lagrange Dynamics - Lagrange Equations and Link

Transformation Matrices.

UNIT III: PATH PLANNING
Cubic Path – Polynomial path - Manipulator motion by Joint path - Cartesian path – Rotational Path - Manipulator motion by end-effector path

UNIT IV: TIME OPTIMAL CONTROL
Minimum time and bang-bang control - Floating Time Method - Time-optimal Control for Robots

UNIT V: CONTROL TECHNIQUES
Open and Closed loop control - Computed Torque Control - Linear Control Technique - Sensing and Control

Text Book:
1. Reza N Jazar , "Theory of Applied Robotics", Springer, 2010.
2. Niku S B, "Introduction to Robotics, Analysis, Control, Applications", John-Wiley & Sons Inc, 2011.

Reference:
1. Mark W. Spong, Seth Hutchinson, M. Vidyasagar, "Robot Modeling and Control", Wiley, 2012.
2. Robert J. Schilling, "Fundamentals of Robotics Analysis and Control", PHI Learning, 2009.
3. Saha S K, "Introduction to Robotics", Tata McGraw Hill Education Pvt. Ltd, 2010.
4. Mark W. Spong, M.Vidyasagar , "Robot Dynamics and Control", Wiley, 2008.

213MEC2311 AUTONOMOUS ROBOTS	L	T	P	X	C
	3	0	2	0	4

Prerequisite: Nil	Course Category: Program Elective Course type: Integrated Course-Theory

Course Objectives:

To present various aspects of design, fabrication, motion planning, and control of intelligent mobile robotic systems.

Course Outcomes:

CO1	Discuss the various types of robot locomotion.
CO2	Demonstrate the kinetic model of a mobile robot and its dynamic simulation.
CO3	Apply the various types of sensors to identify the robot perception.
CO4	Identify the localization of robotic systems.
CO5	Use the concepts of planning and navigation of mobile robots.

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	1	2	2	3	6	5	5	5	7	4	6	6	1,2	3,4,7	2,6
CO1	3	3		2	2								2	1	1
CO2	2		3	2						1			2		
CO3	3	2			1								1		
CO4	2		1	3										1	1
CO5	2	2	1	1			2			1			1		

Course Topics

UNIT 1: ROBOT LOCOMOTION

Types of locomotion, hopping robots, legged robots, wheeled robots, stability, maneuverability, controllability.

UNIT 2: MOBILE ROBOT KINEMATICS AND DYNAMICS

Forward and inverse kinematics, holonomic and nonholonomic constraints, kinematic models of simple car and legged robots, dynamics simulation of mobile robots.

UNIT 3: PERCEPTION

Proprioceptive/Exteroceptive and passive/active sensors, performance measures of sensors, sensors for mobile robots like global positioning system (GPS), Doppler effect-based sensors, vision based sensors, uncertainty in sensing, filtering.

UNIT 4: LOCALIZATION
Odometric position estimation, belief representation, probabilistic mapping, Markov localization, Bayesian localization, Kalman localization, positioning beacon systems.

UNIT 5: INTRODUCTION TO PLANNING AND NAVIGATION
Path planning algorithms based on A-star, Dijkstra, Voronoi diagrams, probabilistic roadmaps (PRM), rapidly exploring random trees (RRT), Markov Decision Processes (MDP), stochastic dynamic programming (SDP).

Practical:

1. Programming in C or Matlab to implement fuzzy logic applications for autonomous robot systems.
2. Programming in C/Matlab to implement simulated annealing/genetic algorithm for solving inverse kinematic problems
3. Programming in C/Matlab to solve traveling salesman problems using ant colony optimization algorithm
4. Write a program using Visual Prolog to create an expert system
5. Write a program for obstacle avoidance in mobile robots using any one algorithm
6. Implement A* algorithm to Solve 8-puzzle problems using. Assume any initial configuration and define goal configuration clearly
7. Define the operators for controlling domestic robot; use these operators to plan an activity to be executed by the robot. For example, transferring two/three objects one over the other from one place to another. Use Means-Ends analysis with all the steps revealed.
8. Solving real time planning and scheduling problems using software like Witness/Pro-model

Text Book:

1. R. Siegwart, I. R. Nourbakhsh, "Introduction to Autonomous Mobile Robots", The MIT Press, 2016.

Reference:

4. Peter Corke, "Robotics, Vision and Control: Fundamental Algorithms in MATLAB", Springer Tracts in Advanced Robotics, 2017.
5. Melgar, E. R., Diez, C. C. "Arduino and Kinect Projects: Design, Build, Blow Their Minds", 2018.

213MEC2312 **INTELLIGENT MEDICAL ROBOTS**		L	T	P	X	C
		3	0	2	0	4
Prerequisite: Nil	Course Category: Program Elective Course type: Integrated Course-Theory					

Course Objectives:

To Provide knowledge on the application of robotics in the field of health care.

Course Outcomes:

CO1	Describe the types of medical robots and the concepts of navigation and motion replication.
CO2	Discuss about the sensors used for localization and tracking
CO3	Summarize the applications of surgical robotics
CO4	Outline the concepts in Rehabilitation of limbs and brain machine interface
CO5	Classify the types of assistive robots.

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	1	2	2	3	6	5	5	5	7	4	6	6	1,2	3,4,7	2,6
CO1	2	2	1	2	2								3	1	1
CO2	2		2	3						1			2	1	
CO3	3	1			1								2		
CO4	2		1	3						1				1	1
CO5	2	2		3			2		1			1	1		

Course Topics

UNIT 1 INTRODUCTION

Types of medical robots - Navigation - Motion Replication - Imaging - Rehabilitation and Prosthetics - State of art of robotics in the field of healthcare.

UNIT 2 LOCALIZATION AND TRACKING

Position sensors requirements - Tracking - Mechanical linkages - Optical - Sound-based - Electromagnetic - Impedance-based - In-bore MRI tracking - Video matching - Fiber optic tracking systems - Hybrid systems.

UNIT 3 CONTROL MODES
Radiosurgery - Orthopedic Surgery - Urologic Surgery and Robotic Imaging - Cardiac Surgery – Neurosurgery – case studies.

UNIT 4 REHABILITATION
Rehabilitation for Limbs - Brain-Machine Interfaces - Steerable Needles – case studies.

UNIT 5 ROBOTS IN MEDICAL CARE
Assistive robots –types of assistive robots – case studies. Characterization of gestures to the design of robots- Design methodologies- Technological choices - Security.

Practical
1. Introduction to Laboratory Equipments
2. Exoskeletons, Ultrasound Imaging Modality and Electromagnetic Tracking System
3. Simulation Study on Robot Dynamics
4. Simulation Study on Robot Kinematics and Control
5. Position Control of a Hand Exoskeleton using Subject's Intention
6. Force Control of a Hand Exoskeleton in Real-Time LabView Platform
7. Needle Maneuverability in Tissue Phantom through Image Guidance
8. Human Hand Biomechanics Study

Text Book:
1. Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, “Robot Modeling and Control”, Wiley Publishers, 2016.
2. Paula Gomes, "Medical robotics- Minimally Invasive surgery", Woodhead, 2019.

Reference:
1. Achim Schweikard, Floris Ernst, “Medical Robotics”, Springer, 2018.
2. Daniel Faust, “Medical Robots”, Rosen Publishers, 2016

UNIVERSITY ELECTIVE COURSES

214MEC1101 BIO AND CHEMICAL PROCESS SAFETY	L	T	P	X	C
	3	0	0	0	3
Prerequisite: Nil	Course Category: University Elective Course type: Theory				

Course Objectives:

To provide an overview of the Safety process followed in chemical and Bio Industry processes.

Course Outcomes:

CO1	Understand the importance of Safety Programs.
CO2	Implement safety procedures in a practical context.
CO3	Interpret and apply the professional obligations related to the discipline of safety and risk management.
CO4	Ability to apply the safety audit concepts and its models.
CO5	Understand the hazardous operation effects and recommendations.

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	1	2	2	3	6	5	5	5	7	4	6	6	1,2	3,4,7	2,6
CO1	1					2	3					1	2		
CO2	2	2				3	1					3	3	3	
CO3	1	2				3		2				3	2	3	2
CO4	2	3				3	2					3	3	2	2
CO5		3				3	2					1	3		

Course Topics

UNIT I: INTRODUCTION

Need for safety in industries; Safety Programmes – components and realization; Potential hazards– extreme operating conditions, toxic chemicals; safe handling

UNIT II: QUALITY CHECKS

Implementation of safety procedures – periodic inspection and replacement; Accidents – identification and prevention; promotion of industrial safety

UNIT III: RISK ANALYSIS

Overall risk analysis--emergency planning-on site & off site emergency planning, risk management ISO 14000, EMS models case studies. Quantitative risk assessment – rapid and comprehensive risk analysis; Risk due to Radiation, explosion due to over pressure, jet fire-fire ball.

UNIT IV: SAFETY AUDITS

Hazard identification safety audits, checklist, what if analysis, vulnerability models event tree analysis fault tree analysis, Hazan past accident analysis Fix borough-Mexico-Madras- Vizag Bopal analysis.

UNIT V: HAZARDOUS OPERATIONS

Hazop-guide words, parameters, derivation-causes-consequences-recommendation-coarse
Hazop study-case studies-pumping system-reactor-mass transfer system.

Text Book:

1. Daniel A. Crowl & Joseph F. Louvar, " Chemical Process Safety: Fundamentals with Applications" Pearson Publications, 4th edition, 2020.

Reference:

1. Center for Chemical Process Safety, "Guidelines for Process Safety in Bioprocess Manufacturing Facilities" Willey Publications, 2011.
2. Center for Chemical Process Safety, "Guidelines for Auditing Process Safety Management Systems" , 1992.

214MEC1301 ROBOTICS : FUNDAMENTAL CONCEPTS	L	T	P	X	C
	3	0	2	0	4
Prerequisite: Nil	Course Category: University Elective Course type: Integrated Course-Theory				

Course Objectives:

To impart the knowledge about the basics of robotics and their kinetics

Course Outcomes:

CO1	Understand the basics of robotics and their geometry
CO2	Enumerate the concepts of homogeneous transformation
CO3	Ability to apply the forward kinematics principles
CO4	Understand the inverse kinematics processes
CO5	Interpret the robotics motion in angular aspects

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	1	2	2	3	6	5	5	5	7	4	6	6	1,2	3,4,7	2,6
CO1	2	3		1	1							2	2	2	1
CO2	3	1		3	1							3	1	1	
CO3	2	2		1	2							2	2	1	1
CO4	3	2		1	1							2	2	2	
CO5	3	1		2	1							2	2	2	2

Course Topics

UNIT I: INTRODUCTION

Classification of Robots based on Geometry, Workspace, Actuation, Control and Application - Advantages and Disadvantages of Robots - Robot Components: Link, Joint, Manipulator, Wrist, End-effector : Gripper –Types, Actuator and Sensor - Configuration space – Joint Space – Workspace, Robot Specifications: Number of Axes:Internal and External (7-axis robot) - Capacity and Speed, Reach and Stroke, Tool Orientation, Repeatability, Precision and Accuracy, Operating Environment

UNIT II: HOMOGENEOUS TRANSFORMATIONS

Degrees of Freedom – Matrix Representation: Representation of a point and vector in space, Global and Local Coordinate axes - Homogeneous Transformation Matrices – Transformations: Representation of pure translation, Representation of pure Rotation - Representation of Combined Transformations - Inverse of Transformation Matrices - Euler Angles – Roll, Pitch, Yaw angles - Quaternions–Spinors and Rotations

UNIT III: FORWARD KINEMATICS

Denavit-Hartenberg Notation - Transformation between two Adjacent Coordinate Frames Forward Kinematics of Two, Three, Four, Five and Six axis Robots

UNIT IV: INVERSE KINEMATICS

Decoupling Technique - Inverse Transformation Technique - Inverse position: GeometricApproach – Inverse Orientation - Inverse Kinematics of Two, Three, Four, Five and Sixaxis Robots.

UNIT V: VELOCITY KINEMATICS

Angular Velocity – Linear Velocity - Jacobian representation of Linear and Angular Velocity Calculation of Jacobian for Two, Three and Four axis Robots - Inverse Jacobian - Singularities: Wrist and Arm Singularities - Manipulability - Induced joint torques and forces.

Practical:

Programming on VAL Language
Programming on VAL-II Language
Programming on RAPID Language
Programming on AML Language
Programming the robot for pick and place operation using any robot
Robot Programming for Colour identification/shape identification/path tracking
Industrial visit and its report on industrial applications of robots

Text Book:

1. Mark W. Spong, Seth Hutchinson, M. Vidyasagar, "Robot Modeling and Control", Wiley, 2015.
2. Niku S B, "Introduction to Robotics, Analysis, Control, Applications", John-Wiley & Sons Inc, 2011.

Reference:

1. Robert J. Schilling, "Fundamentals of Robotics, Analysis and Control", PHI Learning, 2009.
2. Reza N Jazar, "Theory of Applied Robotics", Springer, 2010.
3. Saha S K, "Introduction to Robotics", Tata McGraw Hill Education Pvt. Ltd, 2010.
4. Tadej Bajd, Matjaž Mihelj, Marko Munih, "Introduction to Robotics", Springer, 2013.

214MEC1102 AUTOMATION SYSTEM DESIGN	L	T	P	X	C
	3	0	0	0	3
Prerequisite: Nil	Course Category: Professional Elective Course type: Theory				

Course Objectives:

To provide the concepts of process automation and system integration principles

Course Outcomes:

CO1	Describe the model of automation system in various industries
CO2	Able to select the motion components for the given applications
CO3	Understand the terminologies and the process of automated assembly
CO4	Design of parts for high speed assembly applications
CO5	Enumerate the economics of automation system design

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	1	2	2	3	6	5	5	5	7	4	6	6	1,2	3,4,7	2,6
CO1	2	2		1	1							2	2	2	1
CO2	1	1		2	1							2	1	1	
CO3	1	2		1	2							2	1	1	1
CO4	3	1		2	1							1	2	2	
CO5	3	1		2	1							2	1	2	2

Course Topics

UNIT I: INTRODUCTION TO PROCESS AUTOMATION

Process Automation – paper industry, packaging industry, food processing industry, Integrated design issues in automation systems, the Mechatronics design process- benefits, modeling of electromechanical systems, bond graph technique, Automation migration strategy - building blocks of automation system

UNIT II: SELECTION OF MOTION COMPONENTS

Selection of motor for automation system, Calculation of inertia force for motor, LM Guide ways, Ball screws, Selection, from the manufacturer‟s catalogue based on the applications.

UNIT III: TRANSFER LINES AND AUTOMATED ASSEMBLY
General terminology-takt time, setup time and cycle time, Automated flow lines with storage buffers. Automated assembly-design for automated assembly, types of automated assembly systems, part feeding devices, analysis of multi-station assembly machines - modular fixturing - Flow line balancing

UNIT IV: DESIGN FOR HIGH SPEED AUTOMATIC ASSEMBLY
Introduction, Design of parts for high speed feeding and orienting, high speed automatic insertion, Analysis of an assembly, General rules for product design for automation – Application of high speed automatic assembly.

UNIT V: SYSTEM INTEGRATION
Issues and systematic approaches, design and simulation using CIROS software,economics of automation systems design and implementation

Text Book:
1. Mikell P Groove, "Automation Production Systems and Computer Integrated Manufacturing", Pearson education, New Delhi, 2016.
2. Geoffery Boothroyd, "Assembly Automation and Product Design", CRC Press, USA, 2016

Reference:
1. DevadasShetty , "Mechatronics System Design", PWS Publishing Company, USA, 2010.
2. Wilfried Voss, "A Comprehensible Guide to Servo Motor Sizing", Copperhill Technologies Corporation, Massachusetts, 2007.

214MEC1103 **ADDITIVE (3D) MANUFACTURING**	L	T	P	X	C
	3	0	0	0	3
Prerequisite: Nil	Course Category: University Elective Course type: Theory				

Course Objectives:

The aim of this course is to make the students to understand the basic concepts and nuances of 3D Printing Technology

Course Outcomes:

CO1	Outline the concepts behind the design consideration required for 3D printing.
CO2	Recognize the basic Knowledge in selecting the 3D Printing materials and their applications
CO3	Summarize the various types of Inkjet technology and its working principles.
CO4	Contrast the Laser technology and its impact on 3D printing
CO5	Interpret the appropriate method for designing and modeling Industrial applications

Mapping of Course Outcomes:

PO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
ASO	**1**	**2**	**2**	**3**	**6**	**5**	**5**	**5**	**7**	**4**	**6**	**6**	**1,2**	**3,4,7**	**2,6**
CO1	2	2	2	1	2							2	2	2	2
CO2	2	1										2	2	2	
CO3	2	1	2		2			1				2	2	2	1
CO4	2	2	2		2			1				2	2	2	1
CO5	2	2										2	2	2	

Course Topics

UNIT I: INTRODUCTION

Introduction; Design considerations – Material, Size, Resolution, Process; Modeling and viewing - 3D; Scanning; Model preparation – Digital; Slicing; Software; File formats

UNIT II: PRINCIPLE

Processes – Extrusion, Wire, Granular, Lamination, Photo polymerisation; Materials - Paper, Plastics, Metals, Ceramics, Glass, Wood, Fiber, Sand, Biological Tissues, Hydrogels, Graphene; Material Selection - Processes, applications, limitations

UNIT III: INKJET TECHNOLOGY

Printer - Working Principle, Positioning System, Print head, Print bed, Frames, Motion control; Print head Considerations – Continuous Inkjet, Thermal Inkjet, Piezoelectric Drop-On-Demand; Material Formulation for jetting; Liquid based fabrication – Continuous jet, Multi jet; Powder based fabrication – Color jet

UNIT IV: LASER TECHNOLOGY

Light Sources – Types, Characteristics; Optics – Deflection, Modulation; Material feeding and flow – Liquid, powder; Printing machines – Types, Working Principle, Build Platform, Print bed Movement, Support structures

UNIT V: INDUSTRIAL APPLICATIONS

Product Models, manufacturing – Printed electronics, Biopolymers, Packaging, Healthcare, Food, Medical, Biotechnology, Displays; Open source; Future trends

.

Text Book:

1. Ian M. Hutchings, Graham D. Martin, “Inkjet Technology for Digital Fabrication”, Edition:1,John Wiley & Sons,2013.
2. Christopher Barnatt, “3D Printing”, Edition:3,Create Space Independent Publishing Platform,2016.

Reference:

1. Christopher Barnatt, “3D Printing: The Next Industrial Revolution”, Edition:2,Create Space Independent Publishing Platform,2014.
2. Ibrahim Zeid, “Mastering CAD CAM”, Edition:1,Tata McGraw-Hill Publishing Co,2007.
3. Joan Horvath, “Mastering 3D Printing”, Edition:1,A Press,2014.

214MEC1104 FUNDAMENTALS OF MICRO AND NANO FABRICATION	L	T	P	X	C
	3	0	0	0	3
Prerequisite: Nil	Course Category: University Elective Course type: Theory				

Course Objectives:

To gain the fundamental knowledge of Micro and Nano Fabrication Process.

Course Outcomes:

CO1	Understand the fundamentals of basic mechanical micro machining processes.
CO2	Describe the processes involved in the beam energy based micro machining.
CO3	Elucidate the concepts involved in the abrasive flow finishing process.
CO4	Outline the Micro and Nano Structure Surface development processes.
CO5	Recognize the classification and effects of nanostructures.

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	1	2	2	3	6	5	5	5	7	4	6	6	1,2	3,4,7	2,6
CO1	2	1	2	2								2	3	1	
CO2	3	1	2	2								2	2	1	2
CO3	3		1	2								3	3	2	
CO4	3	1	3	2								3	3	2	2
CO5	3		1	2								3	3	3	

Course Topics

UNIT I: PHYSICAL PROCESSES

Mechanical Micro machining – Ultrasonic Micro Machining – Abrasive Jet Micromachining – Water Jet Micro Machining – Abrasive Water Jet Micro Machining – Micro turning – Chemical and ElectroChemical Micro Machining – Electric discharge micromachining

UNIT II: BEAM BASED PROCESSES

Beam Energy based micromachining – Electron Beam Micro Machining – Laser Beam Micro Machining – Electric Discharge Micromachining – Ion Beam Micro Machining –Plasma Beam

MicroMachining – Hybrid Micro machining – Electro Discharge Grinding – Electrochemical spark micromachining – Electrolytic in process Dressing.

UNIT III: ABRASIVE AND MAGNETIC BASED PROCESSES

Abrasive Flow finishing – Magnetic Abrasive Finishing – Magneto rheological finishing – MagnetoRheological abrasive flow finishing - Magnetic Float polishing – Elastic Emission Machining – chemo mechanical Polishing.

UNIT IV: OTHER MICRO FABRICATION PROCESSES

Micro extrusion – Micro and Nano structured surface development by Nano plastic forming and Roller Imprinting – Micro bending with LASER – LASER micro welding – Electron beam for micro welding.

UNIT V: MICROSTRUCTURAL PROPERTIES

Classification of nanostructures – Effects of nanoscale dimensions on various properties –Effect of nanoscale dimensions on mechanical properties - vibration, bending, fracture Nanoparticles, Sol-Gel Synthesis, Inert Gas Condensation, High energy Ball Milling, Plasma Synthesis, Electro deposition and other techniques. Synthesis of Carbon nano tubes – Solid carbon source-based production techniques – Gaseous carbon source-based production techniques –Top down and bottom-up processes.

Text Books

1. Mcgeough.J.A., Micromachining of Engineering Materials, CRC press 2001, ISBN-10:0824706447.
2. Jain V.K., ‘Introduction to Micromachining’ Narosa Publishing House, 2011

Reference:

1. Bandyopadhyay. A.K, Nano Materials, New age international publishers, New Delhi, 2008, ISBN:8122422578.
2. Jain V.K., Advanced Machining Processes, Allied Publishers, Delhi, 2002
3. Jain V. K., Micro Manufacturing Processes, CRC Press, Taylor & Francis Group, 2012

214MEC1105 SMART MANUFACTURING AND INDUSTRY 4.0	L	T	P	X	C
	3	0	0	0	3

Prerequisite: Nil	Course Category: Professional Elective Course type: Theory with practical

Course Objectives:

To provide students with the concepts of planning manufacturing systems, computer integrated manufacturing and enterprise integration, group Technology and knowledge based systems.

Course Outcomes:

CO1	Assess the performance of manufacturing systems and CIM systems.
CO2	Develop a systematic approach for design and implementation of manufacturing systems.
CO3	Interpret new procedures to improve the productivity of existing manufacturing systems.
CO4	Enumerate the model and algorithm of Group Technology.
CO5	Analyze the impact of knowledge based group technology systems in automated manufacturing system.

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	**1**	**2**	**2**	**3**	**6**	**5**	**5**	**5**	**7**	**4**	**6**	**6**	**1,2**	**3,4,7**	**2,6**
CO1	2	3		2	2		1					2	3	1	2
CO2	1	3		3	2							1	2	2	2
CO3	1	1		2			1					3	3	1	
CO4	1	1		3	2		1					3	3	2	
CO5	1	2		2								2	3	2	

Course Topics

UNIT I: COMPUTER INTEGRATED MANUFACTURING

Computer integrated manufacturing systems – structure and functional areas of CIM system - AD, CAPP, CAM, CAQC, ASRS and advantages of CIM Manufacturing communication systems – MAP/TOP OSI model, data redundancy, top-down and bottom-up approach, volume of information. Intelligent manufacturing – system components, system architecture and data flow, system operation

UNIT II: ARTIFICIAL INTELLIGENCE

Components of knowledge-based systems – basic components of knowledge-based systems, knowledge representation, comparison of knowledge representation schemes, interference engine, knowledge acquisition Machine learning – concept of artificial intelligence,

UNIT III: PROCESS PLANNING

Automated process planning – variant approach, generative approach, expert systems for process planning, feature recognition, phases of process planning Knowledge Based System for Equipment Selection – Manufacturing system design, equipment selection problem, modelling the manufacturing equipment selection problem, problem solving approach in KBSES, structure of the KBSES

UNIT IV: GROUP TECHNOLOGY

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.

UNIT V: KNOWLEDGE BASE

Knowledge based group technology - group technology in automated manufacturing system, structure of knowledge-based system for group technology – database, knowledge base, clustering algorithm

Text Book:

1. Mikell P. Groover, “Automation, Production Systems and Computer Integrated Manufacturing”, 8th edition, PHI, 2008.
2. Alasdair Gilchrist, “Industry 4.0: The Industrial Internet of Things”, A press, 2016.

Reference:

1. Yagna Narayana, “Artificial Neural Networks”, PHI, 2009.
2. Andre Kusaic, “ Intelligent Manufacturing Systems”, PHI,1989
3.Hamid R. Parsaei and Mohammad Jamshidi, “Design and Implementation of Intelligent Manufacturing Systems”, PHI, 2009

214MEC1106 MACHINE LEARNING ENGINEERING FOR PRODUCTION	L	T	P	X	C
	3	1	0	0	4
Prerequisite: Nil	Course Category: Elective Course type: Theory				

Course Objectives:

Course Outcomes:

CO1	Identify the various components and design an ML production system end-to-end
CO2	Build data pipelines by gathering, cleaning, and validating datasets and assessing data quality
CO3	Build models for different serving environments
CO4	Use analytics tools and performance metrics to address model fairness
CO5	Deliver deployment pipelines by productionizing, scaling, and monitoring model serving that require different infrastructure

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	1	2	2	3	6	5	5	5	7	4	6	6	1,2	3,4,7	2,6
CO1	2	2	2	2									2	2	2
CO2	2	2	2	2									2	2	2
CO3	2	2	2	2									2	2	2
CO4	2	2	2	2									2	2	2
CO5	2	2	2	2									2	2	2

Course Topics

UNIT I: INTRODUCTION TO MACHINE LEARNING IN PRODUCTION

Identify the key components of the ML lifecycle and pipeline and compare the ML modeling iterative cycle with the ML product deployment cycle. Identify the key challenges in model development and understand how performance on a small set of disproportionately important examples may be more crucial than performance on the majority of examples. Compare the various types of problems to be solved for structured vs. unstructured data and big vs. small data and understand why label consistency is essential and how you can improve it

UNIT II: MACHINE LEARNING DATALIFECYCLE IN PRODUCTION
Identify responsible data collection for building a fair ML production system. Implement feature engineering, transformation, and selection with TensorFlow Extended by encoding structured and unstructured data types and addressing class imbalances Understand the data journey over a production system's lifecycle and leverage ML metadata and enterprise schemas to address quickly evolving data. Combine labeled and unlabeled data to improve ML accuracy and augment data to diversify your training set

UNIT III: MACHINE LEARNING MODELLING PIPELINES IN PRODUCTION
Learn how to effectively search for the best model that will scale for various serving needs while constraining model complexity and hardware requirements. Learn how to optimize and manage the compute, storage, and I/O resources your model needs in production environments during its entire lifecycle. Implement distributed processing and parallelism techniques to make the most of your computational resources for training your models efficiently.

UNIT IV: MODEL ANALYSIS AND INTERPRETABILITY
Use model performance analysis to debug and remediate your model and measure robustness, fairness, and stability. Learn about model interpretability – the key to explaining your model's inner workings to laypeople and expert audiences and how it promotes fairness and helps address regulatory and legal requirements for different use cases.

UNIT V: DEPLOYING MACHINE LEARNING MODELS IN PRODUCTION
Deliver deployment pipelines by productionizing, scaling, and monitoring model serving that require different infrastructure. Establish procedures to mitigate model decay and performance drops. Establish best practices and apply progressive delivery techniques to maintain and monitor a continuously operating production system

Text Book:

1. Andiry Burkov, Machine Learning Engineering, September 2020,True Positive In

Reference(s):

1. Peter Flaunch, Machine Learning: The Art and Science of Algorithms that Make Sense of Data 1st Edition, 2012, Cambridge University Press.

214MEC1107 **DATA SCIENCE IN MANUFACTURING PRACTICE**	L	T	P	X	C
	3	1	0	0	4
Prerequisite: Nil	Course Category: Elective Course type: Theory				

Course objectives:

Course Outcomes:

CO1	Understand the importance of statistics for data analysis
CO2	Analyze representative samples of large data sets
CO3	Establish a relationship between two or more objects
CO4	Make machines or computers interpret human language
CO5	Create data visualization models

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	1	2	2	3	6	5	5	5	7	4	6	6	1,2	3,4,7	2,6
CO1	2	2	2	2									2	2	2
CO2	2	2	2	2									2	2	2
CO3	2	2	2	2									2	2	2
CO4	2	2	2	2									2	2	2
CO5	2	2	2	2									2	2	2

Course topics

UNIT I: STATISTICS

Important statistical concepts used in data science, Difference between population and sample Types of variables, Measures of central tendency, Measures of variability, Coefficient of variance

UNIT II: INTERFERENTIAL STATISTICS

Skewness and Kurtosis, Normal distribution, Test hypotheses, Central limit theorem, Confidence interval, T-test, Type I and II errors, Student's T distribution

UNIT III: REGRESSION AND ANOVA, EXPLORATORY ANALYSIS

Regression, ANOVA, R square, Correlation and causation, Data visualization, Missing value analysis, The correction matrix, Outlier detection analysis

UNIT IV: SUPERVISED MACHINE LEARNING

Python Scikit tool, Neural networks, Support vector machine, Logistic and linear regression Decision tree classifier

UNIT V: TABLEAU

Working with Tableau, Deep diving with data and connection, Creating charts, Mapping data in Tableau

Text Book:

1. Li Ping Chu, Data Science for Modern Manufacturing, 2016, O'Reilly Media,

HONOURS ELECTIVE

213MEC4101 FRACTURE MECHANICS	L	T	P	X	C
	3	1	0	0	4
Prerequisite: Nil	Course Category: Honours Elective Course type: Theory				

Course Objectives:

Course Outcomes:

CO1	Understand the fundamentals behind fracture mechanics
CO2	Understand the phenomenon of energy release rate in fracture creation
CO3	Obtain solutions based on theory of elasticity
CO4	Develop equations for crack tip stress and displacement field
CO5	Model deformation and fractures through theoretical model

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	1	2	2	3	6	5	5	5	7	4	6	6	1,2	3,4,7	2,6
CO1															
CO2															
CO3															
CO4															
CO5															

Course Topics

UNIT I: OVERVIEW OF ENGINEERING FRACTURE MECHANICS

EFM Course Outline - Spectacular Failures – Lessons from Spectacular Failures- LEFM and EPFM Historical development- Fracture Mechanics is Holistic -Fatigue Crack Growth Model-Crack Growth and Fracture Mechanisms

UNIT II: ENERGY RELEASE RATE

Elastic Strain Energy - Fracture Strength by Griffith - Energy Release Rate - Utility of Energy Release Rate - Pop-in Phenomenon

UNIT III: REVIEW OF THEORY OF ELASTICITY

Displacement and Stress Formulations Simply connected and multiply connected domains, Displacement and stress formulations, Compatibility conditions, Plane stress and plane strain situations, Airy's stress function, Semi-inverse method, Forms of stress functions in Cartesian co-ordinates. Forms of Stress Functions Solution to the problem of a beam under uniformly distributed loading, Forms of stress function in polar co-ordinates, List of problems that could be solved, Illustration of principle of superposition, Analytic functions.

UNIT IV: CRACK-TIP STRESS AND DISPLACEMENT FIELD EQUATIONS
Airy's Stress Function for Mode-I -Cauchy-Riemann conditions-Westergaard Solution of Stress Mode-I -Displacement Field for Mode-I -Relation between KI and GI-Stress Field in Mode-II-Generalised Westergaard Approach -William's Eigen Function- Multi-parameter Stress Field Equations- Multi-parameter Stress Field Equations

UNIT V: SIF'S, MODELING OF PLASTIC ZONE, FRACTURE TOUGHNESS TESTING
Evaluation of SIF for Various Geometries- SIF for Embedded Cracks - SIF for Surface Cracks - Modeling of Plastic Deformation Irwin's Model - Dugdale model- Fracture toughness test-Plane Strain Fracture Toughness Testing - Plane Stress Fracture Toughness Testing.

Text Book:
1. Prashant Kumar, Elements of Fracture Mechanics, Tata McGraw Hill, New Delhi, India, 2019.
2. K. Ramesh, e-Book on Engineering Fracture Mechanics, IIT Madras, 2007

Reference:
1. K.R.Y. Simha, Fracture Mechanics for Modern Engineering Design, Universities Press (India) Limited, 2001
2. D. Broek, Elementary Engineering Fracture Mechanics, Kluwer Academic Publishers, Dordrecht, 1986. 5. T.L. Anderson, Fracture Mechanics – Fundamentals and Applications, 3rd Edition, Taylor and Francis Group, 2005

213MEC4102 **TRIBOLOGY**		L	T	P	X	C
		3	1	0	0	4
Prerequisite: Nil	Course Category: Honours Elective Course type: Theory					

Course Objectives:

The aim of undergoing this course is to provide broad based understanding of the interdisciplinary subject ‘tribology’ and its technological significance

Course Outcomes:

CO1	Explain the surface friction and types of wear at different conditions
CO2	Outline the theories of lubrication, lubrication regimes, theories of hydrodynamic, elasto hydrodynamic etc
CO3	Identify suitable wear testing equipment and standard procedure for different applications.
CO4	Apply suitable frictional components to reduce frictional wear.
CO5	Evaluate the various tribological instruments with international standards.

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	1	2	2	3	6	5	5	5	7	4	6	6	1,2	3,4,7	2,6
CO1	3	2	2							1			2	1	
CO2	3	2	1	1						1			2	1	
CO3	3	3	2	2	2					1	1	1	2	1	
CO4	3	3	3	2	2					1	1	1	2	1	2
CO5	3	3	2	2	2					1	1	1	2	1	2

Course Topics

UNIT I: SURFACE FRICTION AND WEAR

Topography of the surfaces - surface features - surface interaction - theory of friction - sliding and rolling friction, friction properties of metallic and non-metallic materials, friction in extreme conditions - wear- types of wear - mechanism of wear - wear resistance materials - surface treatment - surface modifications - surface coatings

UNIT II: LUBRICATION THEORY

Lubricants-physical properties, lubricants standards, lubrication regimes - hydrodynamic lubrication - Reynolds equation - thermal, inertia and turbulent effects - elasto hydrodynamic, plasto hydrodynamic and magneto hydrodynamic lubrication - hydro static lubrication - gas lubrication

UNIT III: WEAR TESTING METHOD

An abrasive wear tester-A rolling sliding wear tester- A pin-on-disc wear tester-Three body wear test.

UNIT IV: APPLICATION OF TRIBOLOGY

Introduction-Rolling Contact Bearings- Gears- Journal Bearings – Off shore bearing, wind turbine sliding bearing

UNIT V: TRIBO MEASUREMENT IN INSTRUMENTATION

Surface Topography measurements – Electron microscope and friction and wear measurements – Laser method – instrumentation - International standards – bearings performance measurements – bearing vibration measurement.

Text Book:

1. Sahoo, “Engineering Tribology”, Edition:1 ,Prentice Hall India Learning Private Limited, 2015.
2. Kenneth Holmberg Allan Matthews Basu, S.K., Senguta, S.N, “Fundamentals of Tribology”,Edition:1,Prentice Hall India Learning Private Limited, 2005.

Reference:

1. Krishan Kant Sharma, “Tribology”, Edition:1 Laxmi Publications ,2016.
2. Stachowiak, “ENGINEERING TRIBOLOGY”, Edition:1,, Butterworth-Heineman UK2005.
3. Basu, S.K, Sengupta,.Ahuja,B, “Fundamentals of Tribology”, Edition:1,Prentice –Hall of India Pvt. Ltd,2010

213MEC4103 **REFRIGERATION AND AIR CONDITIONING**		L	T	P	X	C
		3	1	0	0	4
Prerequisite: Nil	Course Category: Honours Elective Course type: Theory					

Course Objectives:

Enable the students to understand the principles and concepts of refrigeration and air conditioning

Course Outcomes:

CO1	Interpret the basic concepts of various refrigeration systems
CO2	Predict the types of refrigerants suitable for the applications considering the environmental issues
CO3	Employ the acquired knowledge to provide solutions for the psychrometric properties.
CO4	Identify the cooling load for a given space and suggest the cooling requirements
CO5	Impart knowledge about the air conditioning equipment and its usage

Mapping of Course Outcomes:

PO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
ASO	**1**	**2**	**2**	**3**	**6**	**5**	**5**	**5**	**7**	**4**	**6**	**6**	**1,2**	**3,4,7**	**2,6**
CO1	3	1		1								2	2	2	
CO2	3	1		1			1	3				2	2	1	
CO3	3	2										2	2		
CO4	3	2	2	1				1				2	2	1	
CO5	3											1	2		

Course Topics

UNIT I: INTRODUCTION

Review of thermodynamic principles of refrigeration, concept of aircraft refrigeration system, Advanced vapour compression refrigeration cycle and system, use of P-H charts, multistage and multiple Evaporator systems, cascade system, COP comparison, Advanced vapour absorption refrigeration system & components, ammonia water and lithium bromide water systems, steam jet refrigeration system

UNIT II: REFRIGERANTS AND APPLICATIONS

Refrigerants - properties - selection of refrigerants, alternate refrigerants, refrigeration plant Controls testing and charging of refrigeration units- applications to refrigeration systems. Ozone depletion and global warming issues

UNIT III: PSYCHROMETRY AND COOLING LOAD CALCULATION

Psychrometric processes-use of psychrometric charts, grand and room sensible heat factors, By pass factor, requirements of comfort air conditioning, comfort charts, factors governing optimum effective temperature, recommended design conditions and ventilation standards

UNIT IV: LOAD

Types of load-design of space cooling load, heat transmission through building, solar radiation, Infiltration, internal heat sources (sensible and latent) ,outside air and fresh air load, estimation of total load-domestic, commercial and industrial systems-central air conditioning systems

UNIT V: AIR CONDITIONING EQUIPMENTS

Air conditioning equipment – air cleaning and air filters, humidifiers ,dehumidifiers, air washers, Condenser, expansion devices, evaporator, cooling tower and spray ponds, elementary treatment of duct design, air distribution system-Thermal insulation of air conditioning systems–applications-car, industry, stores and public buildings.

Text Book:

1. Arora, Domkundwar, “A course in Refrigeration and Air conditioning”, Edition:1,Dhanpat Rai and CO. (P) Ltd,2018.
2. Manohar Prasad, “Refrigeration and Air Conditioning”, Edition:3,New Age International,2018.

Reference:

1. C. P. Arora, “Refrigeration and AirConditioning”, Edition:3,TataMcGraw Hill,2014.
2. Roy.J. Dossat, “ Principles of Refrigeration”, Edition:4,Pearson Education,1985.
3. Jordon and Prister, “Refrigeration and Air Conditioning”, Edition:2,Prentice Hall of India Pvt. Ltd,1985.

213MEC4104 MICROELECTROMECHANICAL SYSTEMS	L	T	P	X	C
	3	1	0	0	4
Prerequisite: Nil	Course Category: Honours Elective Course type: Theory				

Course Objectives:

The objective of this course is to make students to gain the knowledge in MEMS

Course Outcomes:

CO1	Understand the basic concept of MEMS and their technology.
CO2	Understand (Ilustrate) the material properties and identify the fabrication process.
CO3	Apply the knowledge to design the Micro and Nano devices for various applications
CO4	Apply the knowledge to design the components by analyzing various techniques.
CO5	Understand (Interpret) the concept of transducer design and their fabrication techniques

Mapping of Course Outcomes:

PO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
ASO	**1**	**2**	**2**	**3**	**6**	**5**	**5**	**5**	**7**	**4**	**6**	**6**	**1,2**	**3,4,7**	**2,6**
CO1	2		3									1	2		
CO2	2	1						1					2	1	
CO3	2		2	1									2		
CO4	2		2	1									2		
CO5	2							1					2		

Course Topics

UNIT I: FUNDAMENTALS OF MEMS

Introduction, history, development and need of micro-electro - mechanical systems, Components of MEMS- overview of MEMS technology

UNIT II: MATERIALS AND FABRICATION PROCESSES

Different electro-physical processes used for machining - dealing with MEMS materials - relevant non - conventional processes - IC fabrication processes used for MEMS - MEMS sensors and actuators.

UNIT III: NANO ELECTRO MECHANICAL SYSTEM

Introduction to Design of NEMS biological and bio systems analogies - Devising and Synthesis of MEMS AND NEMS - MEMS Motion Micro devices Classifier – Synthesis Nano electromechanical Systems Modeling of Micro- and Nano-scale Electromechanical Systems – Devices, Structures and its Applications

UNIT IV: DESIGN CONSIDERATION

Design consideration – process design-mechanical design –design of silicon die-design of micro fluidic network systems-capillary electrophoresis network system

UNIT V: MEMS AND NEMS

Design and Fabrication Analysis of Translational Micro-transducers - Single-Phase Reluctance, Micro-motors -Modeling, Analysis, and Control - Three-Phase Synchronous Reluctance Micro-motors Micro-fabrication Magnetization, Dynamics of Thin Films Microstructures – Micro-transducers With Permanent Magnets.

Text Book:

1. Tai Ran Hsu, “MEMS and MICROSYSTEMS Design and Manufacture”, Edition: 1, McGraw Hill Education , 2017.
2. Vijay K Varadan, “Micro Sensors, MEMS, and Smart Devices”, Edition: 1, John Wiley and sons , 2001.

Reference:

1. MarcMadou, “Fundamentals of micro fabrication”, Edition: 3, CRC Press , 2011.
2. Vijay K. Varadan, K. J. Vinoy, K. A. Jose, “RF MEMS and Their Applications”, Edition: 1, John Wiley & Sons , 2003.
3. Stephen Beeby, “MEMS Mechanical Sensors”, Edition: 1, Artech House , 2004.

213MEC4105 ROBOT MECHANISM DESIGN	L	T	P	X	C
	3	0	2	0	4

Prerequisite: Nil	Course Category: Honours Elective Course type: Integrated Course-Theory

Course Objectives:

Emphasize on how to work with hardware and to be involved in controlling the robot using motors and controllers.

Course Outcomes:

CO1	Introduce the concepts of Robot drive mechanism, Robot operating system (ROS) and Simulation.
CO2	Analyse the design and workings of ChefBot hardware and a selection of the interfacing of different actuators used in this robot with Tiva C Launchpad controller.
CO3	Evaluate the working of different sensors and its inertia measurements.
CO4	Interface the vision sensors with ROS and process the images that it senses using vision libraries such as OpenCV.
CO5	Design a GUI for a Robot using Python

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	1	2	2	3	6	5	5	5	7	4	6	6	1,2	3,4,7	2,6
CO1	2		1		2					2			1		1
CO2	2				2					2			1		1
CO3	2	1			2					2					1
CO4	2	1			2					2			1		1
CO5	2		1		2					2			1		1

Course Topics

UNIT I: BASICS OF ROBOTICS AND SIMULATION

History – Definition – Components – Building a robot – The Robot drive mechanism. Robot Simulation: Mathematical modelling of the robot - Robot kinematics – Concepts of ROS and Gazebo.

UNIT II: DESIGNING CHEFBOT HARDWARE
Specifications - Block diagram - Working with Robotic Actuators and Wheel Encoders - Interfacing DC geared motor with Tiva C LaunchPad - Interfacing quadrature encoder with Tiva C Launchpad - Working with Dynamixel actuators.

UNIT III: WORKING WITH ROBOTIC SENSORS
Working with ultrasonic distance sensors - Working with the IR proximity sensor - Working with Inertial Measurement.

UNIT IV: PYTHON AND ROS
Introduction to OpenCV, OpenNI, and PCL - Programming Kinect with Python using ROS, OpenCV, and OpenNI - Working with Point Clouds using Kinect, ROS, OpenNI, and PCL.

UNIT V: INTERFACING IT INTO ROS, USING PYTHON
Building ChefBot hardware - Writing a ROS Python driver for ChefBot - Understanding ChefBot ROS launch files - Working with ChefBot Python nodes and launch files - The Calibration and Testing of ChefBot - The Calibration of Xbox Kinect using ROS - Wheel odometry calibration - Testing of the robot using GUI.

<u>Practical</u>

1. Computer program for analysis and synthesis of any mechanism and test it.
2. Determination of holding torque in epicyclic gear train.
3. Design of cams and followers
4. Experiment on Robot forward kinematic analysis
5. Experiment on Robot inverse kinematic analysis
6. Determination of mass moment of inertia and radius of gyration of robotic links.
7. Experiment on balancing of mass.

Text Book:
1. JLentin Joseph, Learning Robotics using Python‖, PACKT Publishing, 2019.
2. Aaron Martinez and Enrique Fernandez, ―Learning ROS for Robotics Programming‖, PACKT Publishing, 2018.

Reference:
1. Bill Smart, Brian Gerkey, Morgan Quigley, ―Programming Robots with ROS: A Practical Introduction to the Robot Operating System‖, O‘Reilly Publishers, 2018.
2. Lentin Joseph ,Robot Operating System for Absolute Beginners: Robotics Programming Made Easy, Apress, 2018.

213MEC4301 **ROBOT COLLABORATIVE SYSTEM DESIGN**		L	T	P	X	C
		3	0	2	0	4
Prerequisite: Nil	Course Category: Honours Elective Course type: Integrated Course-Theory					

Course Objectives:

To provide a brief introduction to robot cognition and collaborative system design.

Course Outcomes:

CO1	Discuss about the basics of robot cognition and perception.
CO2	Illustrate the different methods of map building and the robot simulation and execution of a program.
CO3	Analyze the various path planning techniques by briefing about the robot's environment and explaining about the programs used .
CO4	Develop knowledge about simultaneous localization and mapping based techniques and paradigms.
CO5	Elaborate the various robot programming packages for display,tele-operation and other applications.

Mapping of Course Outcomes:

PO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
ASO	**1**	**2**	**2**	**3**	**6**	**5**	**5**	**5**	**7**	**4**	**6**	**6**	**1,2**	**3,4,7**	**2,6**
CO1	3	3		2	2								2	1	1
CO2	2		3	2						1			2		
CO3	3	2			1								1		
CO4	2		1	3										1	1
CO5	2	2	1	1			2			1			1		

Course Topics

UNIT I: CYBERNETIC VIEW OF ROBOT COGNITION AND PERCEPTION

Introduction to the Model of Cognition, Visual Perception, Visual Recognition, Machine Learning, Soft Computing Tools and Robot Cognition.

UNIT II: MAP BUILDING

Introduction, Constructing a 2D World Map, Data Structure for Map Building, Explanation of the Algorithm, An Illustration of Procedure Traverse Boundary, An Illustration of Procedure Map Building, Robot Simulation, Execution of the Map Building Program.

UNIT III: RANDOMIZED PATH PLANNING

Introduction, Representation of the Robot's Environment, Review of configuration spaces, Visibility Graphs, Voronoi diagrams, Potential Fields and Cell Decomposition, Planning with moving obstacles, Probabilistic Roadmaps, Rapidly exploring random trees, Execution of the Quad tree-Based Path Planner Program.

UNIT IV: SIMULTANEOUS LOCALIZATION AND MAPPING (SLAM)

Problem Definition, Mathematical Basis, Examples: SLAM in Landmark Worlds, Taxonomy of the SLAM Problem, Extended Kalman filter, Graph-Based Optimization Techniques, ParticleMethods Relation of Paradigms.

UNIT V: ROBOT PROGRAMMING PACKAGES

Robot Parameter Display, Program for BotSpeak, Program for Sonar Reading Display, Program for Wandering Within the Workspace, Program for Tele-operation, A Complete Program for Autonomous Navigation.

Text Book:

1. Patnaik, Srikanta, "Robot Cognition and Navigation - An Experiment with Mobile Robots", SpringerVerlag Berlin and Heidelberg, 2017.
2. Howie Choset, Kevin LynchSeth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun, “Principles of Robot Motion-Theory, Algorithms, and Implementation”, MIT Press, Cambridge, 2015.

Reference:

1. Sebastian Tharun, Wolfram Burgard, Dieter Fox, “Probabilistic Robotics”, MIT Press, 2015.
2. Margaret E. Jefferies and Wai-Kiang Yeap, "Robotics and Cognitive Approaches to Spatial Mapping", Springer-Verlag Berlin Heidelberg 2018.
3. Hooman Somani,”Cognitive Robotics”, CRC Press, 2015.

213MEC4106 ADVANCED FLUID DYNAMICS		L	T	P	X	C
		3	1	0	0	4
Prerequisite: Nil	Course Category: Honours Elective Course type: Theory					

Course Objectives:

Course Outcomes:

CO1	Understand the basic concepts and properties related to fluid dynamics
CO2	Develop generalized forms of Bernoulli's equation for different models
CO3	Deduce methods for Reynold number approximation
CO4	Apply the theories of turbulence
CO5	Develop the governing equations for normal shocks

Mapping of Course Outcomes:

PO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ASO	1	2	2	3	6	5	5	5	7	4	6	6	1,2	3,4,7	2,6
CO1	2	2	2	2									2		
CO2	2	2	2	2									2		
CO3	2	2	2	2									2		
CO4	2	2	2	2									2		
CO5	2	2	2	2									2		

Course Topics

UNIT I: REVIEW OF BASIC CONCEPTS AND FLUID PROPERTIES

Basic law of Fluid Motion, Internal stresses and external forces on fluid elements, Review of Concepts of Kinematics of fluid motion, vorticity, circulation, velocity potential and stream function, irrotational flow. Governing Equations of Fluid Flow in Differential Form: Navier –

Stokes Equation and exact solutions, Energy equation and solution of fluid flow with thermal effects

UNIT II: DYNAMICS OF IDEAL FLUID MOTION

Applications, Integrations of Euler's Equation of Motion, Generalized form of Bernoulli Equation, Potential flows, Principle of Superposition. Low Reynolds number Approximation of Navier – Stokes Equation: Creeping flow over sphere, Stokes and Oseen approximation, Hydrodynamic Theory of Lubrication.

UNIT III: HIGH REYNOLDS NUMBER APPROXIMATION

Prandtl's Boundary Layer Equations, Laminar Boundary Layer over a flat plat, Blausius solution, Falkner – Skan solution, Approximation method for solution of Boundary Layer Equation, Momentum Integral methods, Holstein and Bohlen method, Thermal Boundary Layer, Reynolds Analogy. Transition to Turbulence: Introduction to Theory of Hydrodynamic Stability, Orr-Sommerfeld equation, Results from transition studies, factor affecting transition and its control.

UNIT IV: FUNDAMENTAL OF TURBULENT FLOWS

Reynolds stress tensor, Phenomenological theories of turbulence, Prandtl's Mixing Length and Eddy Viscosity concepts, Universal Velocity distribution, Laws of the Wall and the Wake. One Dimensional Isentropic Flow: General features, Working equations, Choking in Isentropic flow, Operation of nozzle, diffuser under varying pressure ratio, performance of real nozzles, applications of isentropic flow.

UNIT V: NORMAL SHOCKS

Introductory remarks, Governing equations, Rankine Hugoniot, Prandtl and other relations, weak shocks, thickness of shocks, normal shocks in ducts, performance of convergent divergent nozzle with shocks, moving shock waves, shocks problems in one dimensional supersonic diffuser, supersonic pitot tube. Flow in constant area duct with friction: Governing equations, Working Formulas and tables, choking due to friction, Performance of long duct, Isothermal flow in long duct and flow in constant area duct with heating and cooling.

Text Book:

1. Advanced Fluid Dynamics, Graebel P, Elsevier publications, 2013

Reference:

1. Advanced Engineering Fluid Dynamics, Muralidhar K, Narosa publications, 2015

213MEC4107 **ANALYSIS OF BASIC MANUFACTURING PROCESS**	L	T	P	X	C
	3	1	0	0	4
Prerequisite: Nil	Course Category: Honours Elective Course type: Theory				

Course Objectives:

Course Outcomes:

CO1	Understand the working principle of advanced metal forming processes
CO2	Understand the methodology for development of powder metallurgy product
CO3	Understand the principles of welding
CO4	Understand the principles of casting
CO5	Understand the principles of extrusion

Mapping of Course Outcomes:

PO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
ASO	**1**	**2**	**2**	**3**	**6**	**5**	**5**	**5**	**7**	**4**	**6**	**6**	**1,2**	**3,4,7**	**2,6**
CO1	2	2	2	2									2	2	2
CO2	2	2	2	2									2	2	2
CO3	2	2	2	2									2	2	2
CO4	2	2	2	2									2	2	2
CO5	2	2	2	2									2	2	2

Course Topics

UNIT I: ADVANCED METAL FORMING

Drawing-Depp drawing, forging, bending, forming, cold processing and polymers, High energy rate forming, incremental forming

UNIT II: POWDER METALLURGY

Powder production, powder treatment, powder characterization, packing and flow characteristics of powders, density testing, porosity. High temperature computation, sintering, metallography of p/m parts, Metal injection molding, self-propagating high temperature synthesis.

UNIT III: WELDING
Arc welding types, weldability and weldability testing, Residual stress and stress relief heat treatment.

UNIT IV: CASTING PROCESS
Pattern making-machines and tools for (to refer John Campbell) pattern making - pattern allowances-gating design-riser design-metallurgical aspects of solidification-metal surfaces reaction-mold surface reaction-transformation zones.

UNIT V: ROLLING AND EXTRUSION PROCESS
Rolling mills-Hot and cold rolling-forces and geometrical relationships on rolling-Deformation lubrication in extrusion-analysis of the extrusion process –extrusion of tubing.

Text Book:
1. S.K.Hajra Choudhury, A.K.Hajra Choudhury and Nirjhar Roy, “Elements of Workshop Technology, Vol: I Manufacturing Processes”, Edition: 16, Media Promoters, 2016.
2. R.K.Rajput, “A Textbook of Manufacturing Technology: Manufacturing Processes”, Second Edition, Lakshmi Publications, 2017.

Reference(s):
1. R.K.Jain, “Production Technology”, Edition: 19, Khanna Publisher, 2019.
2. P.Mikell Groover, “Fundamentals of Modern Manufacturing: Materials, Processes, and Systems”, Edition: 7, Wiley, 2018.